

# Planktonic Foraminifera of Paleocene and Early Eocene Age from the Gulf and Atlantic Coastal Plains

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## Introduction

THERE HAS LONG BEEN controversy concerning the geologic age of nearly every formation throughout the world referable to an age somewhere between the Upper Cretaceous Maestrichtian and the Eocene Ypresian. This is none the less true of the formations here discussed which occur along the Gulf and Atlantic Coastal Plains. The differing methods used in the past to determine the age and correlation, range from solely lithologic and structural evidence to paleontologic correlations variously based on brachiopods, mollusks, bryozoa, ostracods, and Foraminifera.

Because the planktonic Foraminifera have come to be recognized in recent years as exceptionally valuable tools for regional and world wide correlations, the writers have made a study of these forms that occur in certain Paleocene and lower Eocene strata. These planktonic species are then made the basis for an inter-regional correlation. The stratigraphic nomenclature and age designations used in this report do not necessarily follow the usage of the U. S. Geological Survey.

Strata from which planktonic species are here described include the Velasco formation of Mexico, the Kincaid and Wills Point formations of the Midway group of Texas; the Pine Barren and McBryde members of the Clayton formation, the Matthews Landung marl member of the Porters Creek clay, the Coal Bluff marl member of the Naheola formation and the Salt Mountain limestone, all of the Midway group of Alabama; the Nanafalia formation of the Wilcox group of Alabama; the Brightseat formation of Maryland, the Aquia formation of Maryland and Virginia, and the Horners-town and Vincentown formations of New Jersey. For purposes of comparison, the planktonic species of the type Danian of Denmark are also described and illustrated. The Wilcox group of Texas and the Porters Creek clay and the Oak Hill member of the Naheola formation of Alabama contained no planktonic Foraminifera, in the samples studied, hence are not further discussed in the present report. Samples of the underlying Cretaceous horizons were also examined in each area, but their quite different faunas are not here described.

## Previous Correlations and Age Assignments

### Velasco Formation

The Velasco formation of the Tampico embayment of Mexico was first separated from the Upper Cretaceous Mendez formation by Cushman and Trager (1924) and was then thought to be related to the Taylor marl of Texas. Later (1926), Cushman stated that it was equivalent to the Navarro of Texas. Dumble and Applin (1924) described the same sequence of beds as Tamest and considered them as lower Eocene.

### Midway Group

The Midway group was originally described from Alabama, and since 1894 has been generally recognized as including the oldest Tertiary beds of the Gulf Coastal Plain. It was long considered by the U. S. Geological Survey to be lower Eocene in age (Wilmarth, 1938, p. 1366). However, about 30 years ago, Gayle Scott (1926, p. 161) had correlated the Midway group of the Gulf Coast with the Danian, placing the nautiloid *Enclimaceras ulrichi* White in the synonymy of *Hercoglossa danica* (Schlotheim). He considered (1934, p. 1158) that the Midway was therefore of Cretaceous age, as the Danian was then generally regarded as late Cretaceous. Gardner (1933, p. 92) first placed the Midway group in the Paleocene, the lower Midway (Kincaid) being considered Montain, and the Upper Midway (Wills Point) correlated with the Landenian. She stated (p. 99) that "The existence of marine deposits of Danian age in either of the Americas has not been established." Brotzen (1948, p. 32) considered the Kincaid as of Danian age, and the Wills Point as Seelandian. He also considered the lower Wilcox to represent the Thanetian and younger stages. His correlations were largely based on benthonic Foraminifera although he mentioned that the Midway "Globigerinidae" occur in the lower Paleocene of Sweden.

### Wilcox Group

The Wilcox group is recognized by the U. S. Geological Survey (Wilmarth, 1938, p. 2333) to be of lower Eocene age, and to designate "deposits overlying the Midway and underlying the Claiborne in the Gulf

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Coastal Plain." Recent studies (Murray, 1955) have shown that the "basal Wilcox" of some areas is a "late Midway" time equivalent. The recognizable sedimentary facies of the Midway and Wilcox groups are thus not entirely time equivalents. The Wilcox is considered to be lower Eocene, yet strata in other areas have been referred to the Wilcox, on lithologic bases, which are faunally much closer to the Midway (Paleocene).

As was demonstrated by Murray (1955), confusion has arisen by the varying usage of the terms Midway and Wilcox by some authors in a lithologic sense (rock unit) and by others in a time connotation (time-rock unit). The greater use of the European stage names or of faunal zones in determining correlations would avoid these misinterpretations.

#### Salt Mountain Limestone

The Salt Mountain limestone of Alabama is recognized by the U. S. Geological Survey to be of lower Eocene age and to belong to the Wilcox group (Wilmarth, 1938, p. 1898). It is regarded as lying between the Tusahoma sand and the Nanafalia formation, although it does not appear in contact with these formations, the only known outcrops being at Salt Mountain and in its immediate vicinity. Toulmin (1941, p. 569) recorded 99 species of Foraminifera from the Salt Mountain, of which 19 were common to the upper Wilcox greensand at Ozark, Alabama, 10 occurred also in the upper Wilcox (Bashi) of Woods Bluff, Alabama, 11 occurred in the lower Midway (Kincaid) of Texas, 18 in the upper Midway of Texas, and 14 were found in common with a Midway fauna in Alabama. Thus the Salt Mountain limestone has about the same number of species in common with the Midway elsewhere as it does with the Wilcox, although Toulmin considered that at least the upper part was younger than Midway and probably of early Wilcox age.

#### Aquia Formation

The Aquia formation of Maryland has been considered by the U. S. Geological Survey to be lower Eocene in age. Cooke and Stephenson (1928) considered the Vincentown formation of New Jersey to be the equivalent of the Aquia formation of Maryland, considering both to be of Wilcox Eocene age. Miller (1956) concurred in this determination, on the basis of megafossils. Shifflet (1948) described the Foraminifera of the Aquia, and stated (p. 17) that the Aquia was "considered equivalent to the lower Wilcox of the Gulf Coast and to the Ypresian of Europe." She recorded nine species of planktonic Foraminifera.

#### Brightseat Formation

The Brightseat formation of Maryland was recently described as of Paleocene age, and underlies the Aquia formation.

#### Vincentown and Hornerstown Formations

Both the Vincentown and Hornerstown formations of New Jersey were originally described as of late Cretaceous age (Clark, Bagg, and Shattuck, 1897, p. 326),

but younger than the Upper Cretaceous of the Gulf Coastal region, and the equivalent of the European Danian stage. Cooke and Stephenson (1928, p. 141) placed these strata in the Eocene (in 1928 the U. S. Geological Survey did not recognize the Paleocene as a distinct epoch), on the basis of macrofossil evidence, as well as diastrophic evidence that the Hornerstown marl transgressed southward on successively older Cretaceous beds. They also correlated the Vincentown formation with the Aquia formation of Maryland. Canu and Bassler (1933, p. 3) correlated the Vincentown with the Maestrichtian and Danian (Upper Cretaceous) of Europe, on the basis of the Bryozoa, but also noted a similarity of the fauna to that of the Aquia of Maryland and the Clayton formation (lower Midway) of the Gulf Coast. Brotzen (1948, p. 32) correlated the Vincentown with the Thanetian, Landenian (Paleocene) and the Ypresian (lower Eocene). McLean (1953, p. 1) identified Paleocene benthonic Foraminifera in the Vincentown, as well as some species suggestive of the Wilcox Eocene, and believed the Vincentown to represent transitional strata.

Fox and Olsson (1955, p. 736) placed the Hornerstown formation in the Paleocene and the Vincentown was said to contain a "mixture of typical Paleocene forms in association with new Eocene elements characteristic of the upper part of the Vincentown." They considered the Vincentown to be "clearly Eocene in age." Hofker (1955, p. 1) listed 22 species of Foraminifera common to the Vincentown and the Paleocene of Europe, and considered the Vincentown to be lower Paleocene.

Miller (1956, p. 731) studied the invertebrate fauna of the Vincentown and concluded that the "strongest affinities are to the Lower Eocene (Aquia) of Maryland and the Danian of Denmark." He recorded 18 species common to the Vincentown and Aquia, including bryozoans, ostracods, alcyonariids, and mollusca. However, as the Aquia was considered lower Eocene, he also correlated the Vincentown with the lower Eocene. He stated (p. 732) that the "*Nautilus*" *danicus*, bryozoans and alcyonariids were also found in the Danian of Europe, but he considered them "facies fossils."

#### Correlation by Planktonic Foraminifera

There is no longer any reason for questionable correlations of marine deposits at the Cretaceous-Tertiary boundary. Wherever planktonic Foraminifera occur they show a very pronounced faunal break. The planktonic genera characteristic of the Cretaceous (*Globotruncana*, *Rugoglobigerina*, *Hastigerinoides*, etc.) are never found in the Cenozoic, and do not occur in the type Danian or in any Paleocene strata. Typical Cenozoic *Globorotalia* and *Globigerina*, such as are found in the Paleocene (Danian, Midway, etc.) the world over, do not appear anywhere in the Cretaceous. Thus a Cretaceous age is definitely excluded for strata in which they appear.

As has been shown by Bolli, Loeblich, and Tappan



this lowermost faunal zone, and restricted to it, are *Globorotalia compressa*, *Globigerinoides daubjergensis* and *Chiloguembelina morsei*. *C. midwayensis* appears in the upper part of the zone.

The Landenian stage (upper Paleocene) contains a *Globigerina*-keeled *Globorotalia* assemblage, and is typified by the species *Globorotalia angulata*. Species typical of the *angulata* zone, which range almost throughout its extent include *Globorotalia angulata*, *G. aequa*, *G. elongata* and *G. pseudomenardii*, in addition to the longer ranging *G. perclara* and *Globigerina triloculinoides*. The *angulata* zone may be further subdivided into subzones, the oldest of which is characterized by *Globorotalia pseudobulloides*. This species first appeared in the late Danian, but does not range above this lower subzone of the Landenian. In addition to the continuance of *Globorotalia pseudobulloides* and *Globigerina triloculinoides*, the subzone notes the first appearance of *Globorotalia angulata*, *elongata*, *pseudomenardii* (all first appearing in the Matthews Landing marl in the Alabama section), and *G. aequa*, *reissi*, and *irrorata* (all appearing first in the Coal Bluff). The *angulata* zone thus represents the beginning of the group of keeled *Globorotalia* which become increasingly numerous in later strata.

The upper subzone of the Paleocene is commonly referred to as the *Globorotalia velascoensis* zone, and is characterized by that very angular and ornate species, and the similar *G. acuta*. The typical *velascoensis* does not range far north of its type region in Mexico, although it does occur in Trinidad. In the Atlantic and Gulf Coastal States it is replaced by the similar *G. acuta*, which has been considered by some to be merely a subspecies of *G. velascoensis*. In the region here studied the faunal subzone is perhaps better typified by *Globigerina spiralis*, which ranges throughout the subzone.

The Hornerstown formation is somewhat transitional between the mid-Paleocene *pseudobulloides* subzone and the upper Paleocene *velascoensis-spiralis* subzone. *Globorotalia pseudobulloides*, *compressa*, and *variata* have disappeared, as have *Chiloguembelina morsei*, and *midwayensis*. The species *Chiloguembelina crinita*, *Globigerina spiralis*, and *Globorotalia angulata*, *aequa*, and *convexa* have taken their place. However, the *G. acuta-velascoensis* group, *G. pseudoscutula*, *occlusa*, and *Globigerina mckannai* do not appear until after the close of Hornerstown time. These species all are present in the upper Velasco, Salt Mountain, Aquia, and Vincentown formations, which thus are closely related faunally.

The lowermost Eocene (Ypresian) typically contains a *Globigerina-Globorotalia-Truncorotaloides* assemblage. In the Gulf and Atlantic coastal region here studied, the lower Eocene is in many places represented by nonmarine sediments, and the only fossiliferous material used in the present study is that of the Nanafalia formation of Alabama. It contains 17 species of planktonic Foraminifera, some of which are holdovers

from the upper Paleocene, but many of the most typical Landenian species are absent. The close of the Paleocene was marked by the disappearance of *Globigerina triloculinoides* (it is replaced in many regions by the similar *G. linaperta*, which is possibly a derivative), *mckannai*, and *spiralis*, and *Globorotalia velascoensis*, *acuta*, *angulata*, *occlusa*, and *pseudoscutula*. The lower Eocene is characterized by the appearance of *Globorotalia rex* (elsewhere also considered a zone fossil for the Ypresian) and *G. pseudotopilensis*. The Landenian, in more offshore marine sections, is also recognized by the first appearance of the genus *Truncorotaloides*, which resembles a sharply angled *Globorotalia*, but with supplementary apertures on the spiral side. True *Truncorotaloides* has not yet been observed in the Nanafalia, although the species, *Globorotalia pseudotopilensis* Subbotina, is similar to those which elsewhere did develop the supplementary apertures.

### Summary

The Danian stage of the lower Paleocene (*compressa-daubjergensis* faunal zone of the *Globigerina* assemblage) is represented by the lower Velasco formation of Mexico; the Kincaid and Wills Point formations, Midway group of Texas; the Pine Barren and McBryde members of the Clayton formation, lower part of the Midway group of Alabama, and the Brightseat formation of Maryland (text-fig. 28).

The lower Landenian stage (Thanetian substage), or middle Paleocene (*angulata* faunal zone, *pseudobulloides* subzone of the *Globorotalia* assemblage), is not represented at the surface in Texas, Maryland, Virginia, or New Jersey. In Alabama it consists of the Porters Creek clay and Naheola formation, the upper part of the Midway group as previously recognized.

The upper Landenian stage (Sparnacian substage) or upper Paleocene (*angulata* faunal zone, *velascoensis-spiralis* subzone) represents the most controversial part of the section. On the basis of the placement elsewhere of the *Globorotalia velascoensis* zone as the uppermost Paleocene, and in view of the greater faunal break above than below this zone, it is here regarded as upper Paleocene. This zone includes the upper Velasco formation of Mexico, the Salt Mountain limestone of Alabama (which is thus shown to be older rather than younger than the Nanafalia formation of the Wilcox group, and is here included as the upper formation in the Midway group although younger than the outcropping Midway of Texas), the Aquia formation of Maryland and Virginia, and the Hornerstown and Vincentown formation of New Jersey.

The lower Eocene (Ypresian stage) is mostly represented by nonmarine sediments in this region, marine strata studied including only the Nanafalia formation of Alabama, which represents the *rex* faunal zone of the *Truncorotaloides* assemblage.

	European Stage	Planktonic Faunal Assemblage	Planktonic Faunal Zone	México	Texas	Alabama	Maryland-Virginia	New Jersey		
EOCENE	YPRESIAN	Globigerina-Globorotalia-Truncorotaloides assemblage	rex zone	Aragón fm	Wilcox group	Wilcox group Nanolalia fm	Nanjemoy	Manasquan marl		
PALEOCENE	LANDENIAN	Spannocian	Globigerina-keeled	Velasco fm	[shaded area]	Midway group Noheala fm Porters Creek clay Cloyton fm	Salt Mountain ls	Aquia fm	Vincetown fm Hornertown fm	
		Thonetian	Globorotalia assemblage				pseudobullicides subzone	Coal Bluff marl mbr.	Oak Hill mbr.	Matthews Landing marl mbr.
	DANIAN	Globigerina assemblage	compressa-daubjergensis zone				Midway group Wills Point fm Kincoid fm	McBryde ls fm Pine Barren fm	Brightseat fm	[shaded area]
CRETACEOUS	MAESTRICHTIAN	Globotruncana assemblage		Méndez fm	Navarra group	Ripley fm	Manmouth fm	Manmouth group		

FIGURE 28.—Correlation table of Paleocene and lower Eocene strata of the Gulf and Atlantic Coastal regions, based on the included planktonic species. Material has been examined from each of the formations marked ♦; all post-Cretaceous planktonic occurrences are shown in the range chart in fig. 27; correlation of those strata which did not contain planktonic species is based on relative stratigraphic position.

### Acknowledgements

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We also are grateful to Dr. John Imbrie of Columbia University, New York City, for making available the

type specimens of the Velasco species described by Maynard White, for some of which lectotypes have here been selected and reillustrated.

Illustrations on the plates are camera lucida drawings, prepared by Patricia and Lawrence Isham, scientific illustrators, U. S. National Museum.

A total of 43 species of planktonic Foraminifera are described and illustrated. Of these, 8 belong to the genus *Globigerina* and one to *Globigerinoides*, in the family Orbulinidae. The family Globorotaliidae is represented by 26 species of *Globorotalia*, and the family Heteroheliciidae by 1 *Heterohelix*, 4 *Chiloguembelina*, 2 *Tubitextularia*, and 1 *Woodringina*. Of the species described, 13 are new.

In the following descriptions, only partial synonymies are given. The original reference is cited and additional references are given only to the local occurrences. Solely on the basis of the literature, it is impossible to state with certainty the actual occurrence of a species without reference to the figured and described material. Therefore, when a reference is given in the synonymies which follow, the type specimens have in general been compared by us with our material. Only the Russian types of certain of the Paleocene species have not been personally studied by us.

## Systematic Descriptions

### Family Heterohelicidae Cushman, 1927

#### Subfamily Guembeltriinae Montanaro Gallitelli, 1957

##### Genus Woodringina Loeblich and Tappan, 1957

*Woodringina claytonensis* Loeblich and Tappan

PLATE 40, FIGURE 6

*Woodringina claytonensis* LOEBLICH and TAPPAN, Journ. Wash. Acad. Sci. vol. 47, p. 39, figs. 1a-d, 1957.

Test free, tiny, flaring rapidly; early stage with a single whorl of three chambers (reduced "triserial"), commonly followed by three, or more rarely up to five, pairs of biserial chambers, the plan of biseriality slightly twisted in development; chambers few in number, subglobular, increasing rapidly in size; sutures distinct, constricted; wall calcareous, finely perforate and very finely hispid; aperture a low, arched slit bordered above by a slight lip, somewhat asymmetrical in position.

Length of holotype 0.15 mm., greatest breadth 0.12 mm. Other specimens vary from 0.12 to 0.22 mm. in length.

REMARKS: This species superficially resembles *Tosaiia hanzawai* Takayanagi from the Pliocene of Japan, but differs in being about one-third as large, in having a reduced "triserial" stage of three chambers, and better developed biserial stage, whereas the Japanese form has a trochoid whorl, followed by a triserial stage, and only an occasional specimen has the poorly developed biserial stage. The chambers of the present species are also more inflated and subglobular.

TYPES AND OCCURRENCE: Holotype (USNM P5685) from the Pine Barren member of the Clayton formation, blue-black micaceous clay exposed in road cut opposite small country store, 0.8 mile west of Alabama River bridge on Alabama state highway 28, Wilcox County, Alabama. Collected by Alfred R. Loeblich, Jr., July 1956.

#### Subfamily Heterohelicinae Cushman, 1927

##### Genus Heterohelix Ehrenberg, 1841

*Heterohelix wilcoxensis* (Cushman and Ponton)

PLATE 56, FIGURES 2a, b

*Gümbelina wilcoxensis* CUSHMAN and PONTON, Contr. Cushman Lab. Foram. Res., vol. 8, pt. 3, p. 66, pl. 8, figs. 16, 17, 1932.

Test free, small, flaring rapidly, with 3 to 5 pairs of nearly globular chambers biserially arranged; sutures distinct, deeply depressed; wall calcareous, finely but distinctly perforate, with perforations aligned in very fine longitudinal striae; aperture a broad symmetrical and relatively high arch.

Length of figured hypotype 0.18 mm.

REMARKS: The figured specimen is only about one-half the size of the holotype, but may be a juvenile specimen as it is identical in all characters to the earlier portion of the holotype. This species is characterized by the perforations aligned in fine longitudinal striae, the globular chambers, and flaring test.

TYPES AND OCCURRENCE: Figured hypotype (USNM P5834) from the Aquia formation, 10 to 13 feet above the base of the exposure, west bank of Potomac River, near mouth of Aquia Creek, S. 10° E. of Brent Point on U. S. Geological Survey Nanjemoy Md.-Va. Quadrangle, 1:62,500, 1913, reprinted 1945. Collected by A. R. Loeblich, Jr., and Richard A. Page.

##### Genus Chiloguembelina Loeblich and Tappan, 1956

*Chiloguembelina erinita* (Glaessner)

PLATES 49, FIGURE 1; 51, FIGURES 1a-3; 56, FIGURES 1a, b; 60, FIGURE 6; 62, FIGURE 1

*Gümbelina erinita* GLAESSNER, Probl. Paleontol., Moscow Univ. Lab. Paleontol., vol. 2-3, p. 383, pl. 4, figs. 34a, b, 1937.

*Gümbelina wilcoxensis* Cushman and Ponton, SHIFFLETT, Maryland Dep. Geol., Mines and Water Resources Bull. 3, p. 60, pl. 3, fig. 8, 1948.

Test free, small, flaring rapidly; 4 to 6 pair of biserially arranged chambers slightly twisted in development, early chambers relatively low and broad, later ones higher and ovate to subglobular; sutures distinct, depressed, straight and slightly oblique; wall calcareous, finely perforate, surface smooth in the early part, with the terminal part finely hispid; aperture a broad open arch, with a narrow lip at one side expanding into a broad apertural flange at the opposite edge, causing the aperture to be directed toward one of the flat sides of the test.

Hypotypes range from 0.20 to 0.30 mm. in length.

REMARKS: This species differs from *C. midwayensis* (Cushman) in being more flaring, in having higher and more globose chambers and a finely spinose wall, especially in the terminal portion.

It differs from *C. morsei* (Kline) in having a more flared and more twisted test, and in the early chambers being broad and low, only the later ones becoming inflated. The apertural flange is also more prominent at one side of the aperture in the present species.

The specimen referred to *Gümbelina wilcoxensis* Cushman and Ponton by Shifflett (1948, p. 60) also belongs to the present species, and differs from *Heterohelix wilcoxensis* (Cushman and Ponton) in lacking the symmetrical aperture characteristic of true *Heterohelix*. *Heterohelix wilcoxensis* also is a much larger and more robust species, with more nearly globular chambers.

TYPES AND OCCURRENCE: Figured hypotypes (USNM P5115a-c) from the Vincentown limesand, along north bluff of Rancocas Creek, 0.3 to 0.5 mile northwest of Vincentown, Burlington County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured hypotype (USNM P5116) from the *Ostrea thirsae* beds of the Nanafolia formation, 56 feet above the Midway contact, in road cut 1.2 miles east of Kimbrough Station, and 0.2 mile east of the Turkey Creek bridge, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5852) from the Aquia formation, 42 feet above the base of the exposure, west bank of Potomac River, near mouth of Aquia Creek, S. 10° E. of Brent Point, on U. S. Geological Survey Nanjemoy Md.-Va. Quadrangle, 1:62,500, 1913, reprinted 1945. Collected by A. R. Loeblich, Jr., and Richard A. Page.

Figured hypotype (USNM P5853) from the Horners-town formation, north bank of Shingle Run, a tributary to Crosswicks Creek, 1.0 mile north of New Egypt, Monmouth County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sahl.

Figured hypotype (USNM P5890) from the Velasco formation, middle bed at road crossing of arroyo half-way between San José de las Rusias and Soto la Marina, Tamaulipas, Mexico. Collected by R. Wright Barker.

This species also occurs in the Salt Mountain limestone of Alabama, and has been recorded from the Aquia formation of Friendly, Maryland.

It was originally described from the Paleocene of the northwest Caucasus, USSR.

#### *Chiloguembelina midwayensis* (Cushman)

PLATES 41, FIGURE 3; 43, FIGURES 7a, b; 45, FIGURES 9a, b

*Gümbelina midwayensis* CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 16, pt. 3, p. 65, pl. 11, fig. 15, 1940.

*Chiloguembelina midwayensis* (Cushman) LOEBLICH and TAPPAN (part); not *Gümbelina morsei* Kline, 1943, Journ. Washington Acad. Sci., vol. 46, No. 11, p. 340, 1956.

Test free, small, flaring rapidly, commonly with about five pairs of biserially arranged, broad and relatively low chambers; sutures distinct, slightly depressed and oblique; wall calcareous, finely perforate, surface smooth, but terminal face of the last pair of chambers may be finely hispid; aperture at the base of the final chamber, a broad open arch, with a prominent apertural flap at one side, causing the aperture to appear directed to one side of the test.

Hypotypes range in length from 0.23 to 0.25 mm.

REMARKS: This species was originally described from the Midway group of Alabama and appears to be restricted to the lower and middle Paleocene. It is here recorded from the McBryde limestone member of the Clayton formation, the Wills Point formation and the Matthews Landing marl member of the Porters Creek clay.

TYPES AND OCCURRENCE: Figured hypotype (USNM P5829) from the McBryde limestone member of the Clayton formation, in bed of Rock Creek, 0.8 mile south of junction of Alabama highways 28 and 10, on highway 10, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5830) from the Matthews Landing marl member of the Porters Creek clay, at

Naheola Landing, Tombigbee River, SE¼, Sec. 30, T. 15 N., R. 1 E., 11 miles east of Jachin, Choctaw County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5831) from the Wills Point formation, 200 feet east of the bridge over Tehuacana Creek, 4 miles north of Mexia on the Mexia-Wortham road, Limestone County, Texas. Collected by A. R. Loeblich, Jr.

#### *Chiloguembelina morsei* (Kline)

PLATES 40, FIGURES 2a, b; 41, FIGURE 4; 42, FIGURES 1a, b; 43, FIGURES 2, 6a, b

*Gümbelina morsei* KLINE, Mississippi Geol. Surv. Bull. 53, p. 44, pl. 7, fig. 12, 1943.

*Chiloguembelina midwayensis* (Cushman) LOEBLICH and TAPPAN (part), Journ. Washington Acad. Sci., vol. 46, No. 11, p. 340, 1956.

Test free, small, relatively narrow and elongate; 5 to 7 pair of biserially arranged subglobular, inflated chambers, of nearly equal breadth and height; sutures distinct, depressed, nearly horizontal; wall calcareous, finely perforate, terminal part finely hispid; aperture a relatively high arch with a narrow, everted lip at one side expanding into a relatively wide apertural flange at the opposite side, and thus directing the aperture somewhat to one of the flat sides of the test.

Hypotypes range from 0.23 to 0.30 mm. in length.

REMARKS: In an earlier paper the present writers (Loeblich and Tappan, 1956, p. 340) considered this species a synonym of *C. midwayensis* (Cushman). Additional material has shown that *C. morsei* can be distinguished by the narrower test, more globular chambers and more deeply constricted sutures. It differs from *C. crinita* (Glaessner) in the less rapidly flaring test and in having globular rather than somewhat low and broad chambers.

TYPES AND OCCURRENCE: Figured hypotype (USNM P5854) from the Danian, calcarenite at Erslev, Mors, north of the village, west of Tøving road, Denmark. Collected by J. C. Troelsen.

Figured hypotype (USNM P5855) from the McBryde limestone member of the Clayton formation, in bed of Rock Creek, 0.8 miles south of the junction of Alabama state highways 28 and 10 on Alabama highway 10, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5856) from the Kincaid formation, in a small stream bank on the east side of the road to Lund, 3 miles northwest of Elgin on the Bastrop-Travis county line, 0.5 miles north of the junction with the Austin-Elgin highway, Texas. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5857) from the Wills Point formation, 200 feet east of the bridge over Tehuacana Creek, 4 miles north of Mexia on the Mexia-Wortham road, Limestone County, Texas. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5858) from the type locality of the Brightseat formation, 1 mile west-southwest of Brightseat and 0.2 mile south of Sheriff Road,

Prince Georges County, Maryland. Collected by A. R. Loeblich, Jr. and Richard A. Page.

This species occurs also in the Pine Barren member of the Clayton formation of Alabama.

*Chiloguembelina* species

PLATE 47, FIGURE 1

REMARKS: A single specimen of *Chiloguembelina* was obtained from the Salt Mountain limestone, which is somewhat poorly preserved, and not here identified specifically. It is larger, thicker and more robust than *C. midwayensis* (Cushman), and is less flaring. It is smaller and less flaring than *Heterohelix wilcoxensis* (Cushman and Ponton), has the eccentric aperture with flap at one side characteristic of *Chiloguembelina*, and the surface is smooth rather than with coarse perforations aligned in longitudinal striae.

Length of figured specimen 0.25 mm.

TYPES AND OCCURRENCE: Figured specimen (USNM P5832) from the Salt Mountain limestone, in a limestone sink, ½ mile north of Salt Mountain, in the NW¼ NW¼, Sec. 34, T. 6 N., R. 2 E., Clarke County, Alabama. Collected by H. T. and A. R. Loeblich, Jr.

Genus *Tubitextularia* Sulc, 1929

*Tubitextularia alabamensis* (Cushman)

PLATE 41, FIGURE 7

*Rectogümbelina alabamensis* CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 16, pt. 3, p. 65, pl. 11, fig. 16, 1940.

Test free, tiny, elongate, early portion generally consisting of 5 pair of biserial chambers followed by 3 cuneate-appearing uniserial chambers; chambers inflated, increasing gradually in size; sutures distinct, depressed, somewhat oblique in both biserial and uniserial stages; wall calcareous, perforate, surface finely hispid; aperture terminal, slightly eccentric, bordered with a slight lip.

Length of figured hypotype 0.23 mm.

REMARKS: This species was originally described from Midway chalk overlying the *Ostrea pulaskensis* bed in Alabama. The species is relatively rare in the Clayton formation of Alabama.

TYPES AND OCCURRENCE: Figured hypotype (USNM P5686) from the McBryde limestone member of the Clayton formation, in bed of Rock Creek, 0.8 mile south of the junction of Alabama highways 28 and 10, on highway 10, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

*Tubitextularia laevigata* Loeblich and Tappan, new species

PLATE 41, FIGURE 6

Test free, small, elongate, early part flaring rapidly, with 4 to 5 pairs of biserially arranged chambers followed by 2 or rarely 3 subglobular uniserial chambers, of somewhat lesser breadth than the preceding biserial stage; sutures distinct, slightly depressed, nearly horizontal; wall calcareous, finely perforate, surface smooth; aperture in the biserial stage at the base of the final

chamber, terminal in the uniserial stage of the adult test, produced on a short fragile neck which is commonly broken.

Length of holotype 0.25 mm.

REMARKS: *Tubitextularia laevigata*, new species, is closest in appearance to *T. midwayensis* (Cushman) with which it is associated. It differs in the larger and more flaring test, more globular uniserial chambers and the smooth rather than hispid wall surface.

TYPES AND OCCURRENCE: Holotype (USNM P5820) from the McBryde limestone member of the Clayton formation, in bed of Rock Creek, 0.8 mile south of the junction of Alabama highways 28 and 10, on highway 10, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Family Orbulinidae Schultze, 1854

Subfamily Globigerininae Carpenter, 1862

Genus *Globigerina* d'Orbigny, 1826

*Globigerina aquiensis* Loeblich and Tappan, new species

PLATES 51, FIGURES 4a-5c; 56, FIGURES 4a-6c

Test free, trochospiral, subglobular to relatively high-spired, periphery broadly rounded, peripheral outline lobulate, umbilicus open; commonly with four subglobular chambers in the final whorl, and may have a smaller thin-walled final chamber somewhat resembling a bulla, but with a normal aperture; sutures distinct, depressed, slightly curved; wall calcareous, perforate, surface finely hispid, most prominently in the umbilical region; aperture umbilical, with a narrow lip, a fairly high open arch.

Holotype 0.28 mm. in diameter, 0.23 mm. in thickness.

REMARKS: *G. aquiensis*, new species, is similar to *G. spiralis* Bolli in being high spired, but differs in being considerably smaller, with fewer and more globular chambers per whorl, and in being finely hispid.

TYPES AND OCCURRENCE: Holotype (USNM P5839) from the Aquia formation, 10 to 13 feet above base of the exposure, west bank of Potomac River, near mouth of Aquia Creek, S. 10° E. of Brent Point on U. S. Geological Survey Nanjemoy Md.-Va. Quadrangle, 1:62,500, 1913, reprinted 1945. Collected by A. R. Loeblich, Jr., and Richard A. Page.

Figured paratypes (USNM P5840a, b) from same locality as above but from 6 to 9 feet above base of the exposure.

Figured paratypes (USNM P5841a, b) from the Vincentown formation, north bank of Rancocas Creek, 0.3 to 0.5 miles northwest of Vincentown, Burlington County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

*Globigerina chascanona* Loeblich and Tappan, new species

PLATES 49, FIGURES 4a-5c; 61, FIGURES 8a-c

Test free, trochospiral, subglobular to high spired, periphery rounded, peripheral outline lobulate, all



chambers of the  $2\frac{1}{2}$  to 3 whorls visible on the spiral side, with earlier whorls distinctly elevated above the level of the 4 to 5 chambers of the final whorl, only the final whorl visible on the umbilical side, final chamber may be somewhat reduced in size and bulla-like; sutures distinct, depressed, slightly curved; aperture a small umbilical arch bordered with a narrow lip.

Greatest diameter of holotype 0.20 mm., height of spire 0.23 mm.

REMARKS: *G. chascanona*, new species, differs from *G. aquiensis*, new species, and *G. spiralis* Bolli in having a very prominently spinose surface, smaller umbilical area, lower aperture, and in being much smaller in size.

The specific name is from the Greek name for cocklebur, *chaskanon*.

TYPES AND OCCURRENCE: Holotype (USNM P5842) and figured paratype (USNM P5843) from the Horners-town formation, north bank of Shingle Run, a tributary to Crosswicks Creek, 1.0 mile north of New Egypt, Monmouth County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured paratype (USNM P5844) from the Nanafalia formation, basal 6 feet of formation, road cut, 0.2 mile east of Turkey Creek bridge, and 1.2 miles east of Kimbrough Station, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Also occurs in the Aquia formation of Virginia.

#### *Globigerina inaequispira* Subbotina

PLATES 49, FIGURES 2a-c; 52, FIGURES 1a-2c; 56, FIGURES 7a-c; 61, FIGURES 3a-c; 62, FIGURES 2a-c

*Globigerina inaequispira* SUBBOTINA, Trudy Vses. Neft. Naukno-Issledov. Geol.-Razved. Inst., new ser., vol. 76, p. 69, pl. 6, figs. 1-4, 1953.

*Globigerina triloculinoides* Plummer, SHIFFLETT, Maryland Dep. Geol., Mines and Water Resources Bull. 3, p. 71, pl. 4, figs. 16, 17, 1948.

Test free, consisting of rapidly enlarging chambers in a low trochospiral arrangement; chambers subglobular, all visible on the spiral side, only the 3 to 4 chambers of the final whorl visible on the umbilical side; sutures distinct, depressed; wall calcareous, finely perforate, surface finely spinose, becoming coarsely spinose in the umbilical region; aperture interiomarginal and umbilical, and may have a narrow bordering lip.

Hypotypes range from 0.23 to 0.48 mm. in greatest diameter and from 0.15 to 0.33 mm. in thickness.

REMARKS: Originally described from the "Lower to Middle Eocene" of Russia in a zone with *Globorotalia velascoensis*, *Globorotalia pseudoscutula*, and *Globigerina triloculinoides* this species is here considered to be of Paleocene age, as the *G. velascoensis* zone is so considered elsewhere. *G. inaequispira* differs from *G. triloculinoides* Plummer in lacking the coarsely reticulate surface and in being finely to prominently spinose.

*G. inaequispira* is similar to *G. linaperta* Finlay which also has a spiny surface, but in *G. linaperta* the surface also shows a reticulate pattern.

The specimens referred to *G. triloculinoides* Plummer by Shifflett (1948) are typical *G. inaequispira*, having

the characteristic spiny surface which is not found in true *G. triloculinoides*.

*G. inaequispira* has a somewhat more restricted geologic range than does *G. triloculinoides* and is found only in strata of middle to late Paleocene (Landenian) age, not in the underlying lower Paleocene (Danian) strata.

TYPES AND OCCURRENCE: Hypotype (USNM P5729) from the Salt Mountain limestone in a limestone sink,  $\frac{1}{2}$  mile north of Salt Mountain in the NW $\frac{1}{4}$ NW $\frac{1}{4}$ , sec. 34, T. 6 N., R. 2 E., Clarke County, Alabama. Collected by H. T. and A. R. Loeblich, Jr.

Figured hypotype (USNM P5730) from the *Ostrea thirsae* beds of the Nanafalia formation, top of section exposed, approximately 56 feet above the Midway contact, in road cut 0.2 mile east of Turkey Creek bridge, 1.2 miles east of Kimbrough Station, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5731) from the Aquia formation, 15 to 17 feet above base, west bank of Potomac River, near mouth of Aquia Creek, S. 10° E. of Brent Point, on U. S. Geol. Survey Nanjemoy Md.-Va. quadrangle, 1:62,500, 1913, reprinted 1945. Collected by A. R. Loeblich, Jr., and Richard A. Page.

Figured hypotype (USNM P5732) from the Horners-town formation, north bank of Shingle Run, a tributary to Crosswicks Creek, 1.0 mile north of New Egypt, Monmouth County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured hypotype (USNM P5117a,b) from the Vincentown formation, along north bluff of Rancoas Creek, 0.3 to 0.5 mile northwest of Vincentown, Burlington County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured hypotype (USNM P5881) from the upper Velasco formation, middle bed at road crossing of arroyo halfway between San José de las Rusias and Soto la Marina, Tamaulipas, Mexico. Collected by R. Wright Barker.

#### *Globigerina mckannai* White

PLATES 47, FIGURES 7a-c; 53, FIGURES 1a-2c; 57, FIGURES 8a-c; 62, FIGURES 5a-7c

*Globigerina mckannai* WHITE, Journ. Paleontol., vol. 2, p. 194, pl. 27, figs. 16a-c, 1928.

*Globorotalia mckannai* (White), BOLLI, U. S. Nat. Mus. Bull. 215, p. 79, pl. 19, figs. 16-18, 1957.

*Globigerina cretacea* var. *esnehensis* NAKKADY, Journ. Paleontol., vol. 24, p. 689, pl. 90, figs. 14-16, 1950.

*Globigerina gravelli* BRONNIMANN, Bull. Amer. Paleontol., vol. 34, No. 143, p. 160, pl. 11, figs. 16-18, 1952.—BOLLI, U. S. Nat. Mus. Bull. 215, p. 72, pl. 16, figs. 1-3, 1957.

*Globigerina* sp., HOFKER, Rep. McLean Foram. Lab., No. 2, p. 15, pl. 5, 1955.

Test free, subglobular to slightly compressed, spiral side convex, in a low trochospiral coil of  $2\frac{1}{2}$  whorls, umbilical side convex with broad open umbilicus, peripheral margin broadly rounded to subtruncate, peripheral outline lobulate; 5 to 6 globular to ovate chambers in the final whorl, commonly 5, increasing regularly in size; sutures distinct, depressed, slightly curved back-

wards on the spiral side, radial on the umbilical side; wall calcareous, surface finely spinose, the spines most prominent in the umbilical region, an occasional specimen has a smaller final chamber which is thin-walled and nearly smooth; aperture interiomarginal, umbilical, in some specimens showing a tendency to extend somewhat to an extraumbilical position, with apertures of earlier chambers all remaining open into the umbilicus.

Hypotypes range from 0.28 to 0.48 mm. in diameter, and 0.20 to 0.35 mm. in thickness.

REMARKS: Originally placed in *Globigerina*, this species was placed in *Globorotalia* by Bolli (1957, p. 79). However, the early umbilical position of the aperture, inflated chambers, rounded periphery, and coarsely spinose surface all show a stronger relationship to *Globigerina* (and the type species *Globigerina bulloides*) than to *Globorotalia* (typified by *Globorotalia tumida*). The gradual migration of the aperture from completely umbilical to a somewhat extraumbilical position can be found in nearly every species of *Globigerina*, if a large suite of specimens is examined. This species is closest in appearance to *Globigerina soldadoensis* Bronnimann, which Bolli did leave in *Globigerina*, although even the holotype of this species has an asymmetrical aperture.

Bolli (1957, p. 72) recorded *Globigerina graveli* Bronnimann as occurring in Trinidad throughout the lower Eocene part of the Lizard Springs formation, although the holotype of Bronnimann's species was from the lower Lizard Springs formation (Paleocene, *Globorotalia velascoensis* zone, sample Rz 287). The specimen figured by Bolli from the upper Lizard Springs formation (of lower Eocene age) as well as the holotype of *graveli* would both easily fall within the variation of *Globorotalia mckannai* White at its type locality (Velasco formation of Mexico, *Globorotalia velascoensis* zone).

*Globigerina mckannai* shows a tendency to develop the somewhat truncate chamber form typical of *Globogadrina*, but differs in lacking the toothlike apertural flaps. This appearance also suggests a relationship with the Orbulinidae, rather than the Globorotaliidae.

*Globigerina soldadoensis* Bronnimann commonly has fewer chambers per whorl, a more rapid increase in chamber size, and thinner chambers.

Specimens of *G. esnehensis* identified by S. E. Nakaya show it to be synonymous with the present species.

TYPES AND OCCURRENCE: Figured hypotypes (USNM P5119a,b) from the Vincentown formation, along north bluff of Rancocas Creek, 0.3 to 0.5 miles northwest of Vincentown, Burlington County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured hypotype (USNM P5120) from the Aquia formation, 14 to 16 feet above base of exposure, west bank of Potomac River, near mouth of Aquia Creek, S. 10° E. of Brent Point, on U. S. Geological Survey Nanjemoy Md.-Va. Quadrangle, 1:62,500, 1913, reprinted 1945. Collected by A. R. Loeblich, Jr., and Richard A. Page.

Figured hypotype (USNM P5833) from the Salt Mountain limestone, in a limestone sink, ¼ mile north of Salt Mountain, in the NW¼ NW¼, Sec. 34, T. 6 N.,

R. 2 E., Clarke County, Alabama. Collected by H. T. and A. R. Loeblich, Jr.

Lectotype (Columbia Univ. 19878), here designated, from the Velasco formation, Columbus Station on the Tampico-Monterey railroad line, Mexico.

Figured hypotypes (USNM P5884a,b) from the Velasco formation, middle bed at road crossing of arroyo halfway between San José de las Rusias and Soto la Marina, Tamaulipas, Mexico. Collected by R. Wright Barker.

*Globigerina* cf. *G. soldadoensis* Bronnimann

PLATE 53, FIGURES 4a-c

Test free, of medium size, globose, periphery broadly rounded; chambers increasing rapidly in size, only the 3½ chambers of the final whorl visible around the deep and open umbilicus of the umbilical side; sutures distinct, slightly depressed, somewhat oblique on the spiral side, radial on the umbilical side; wall calcareous, finely perforate, surface covered with short blunt spines, aperture interiomarginal, umbilical, or extending slightly to an extraumbilical-umbilical position.

Figured specimen 0.33 mm. in diameter.

REMARKS: This form differs from typical *G. soldadoensis* Bronnimann in being more globose, with more evenly rounded chambers and less incised sutures. It is somewhat similar to the associated *G. mckannai* White, but differs in having fewer chambers per whorl, a more broadly rounded periphery and a flatter spire.

TYPES AND OCCURRENCE: Figured specimen (USNM P5130) from the Vincentown formation, north bluff of Rancocas Creek, 0.3 to 0.5 miles north of Vincentown, Burlington County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

*Globigerina spiralis* Bolli

PLATES 47, FIGURES 3 a-c; 49, FIGURES 3 a-c; 51, FIGURES 6 a-9 c; 53, FIGURES 3 a-c

*Globigerina spiralis* BOLLI, U. S. Nat. Mus. Bull. 215, p. 70, pl. 16, figs. 16-18, 1957.

*Globigerina* cf. *ouachitensis* Howe and Wallace, SHIFFLET, Maryland Dep. Geol., Mines and Water Resources Bull. 3, p. 71, pl. 4, figs. 11-13, 1948.

Test free, the high trochospiral coiling resulting in a nearly globular test; chambers globular, increasing rapidly in size, those of the 2 to 3 whorls all visible on the spiral side, only the 4 to 6 chambers of the final whorl visible on the umbilical side, umbilicus open, rare specimens may have the umbilicus nearly closed (pl. 51, fig. 6); sutures distinct, depressed; wall calcareous, perforate, surface finely to moderately spinose, most prominently so in the umbilical region; aperture a broad umbilical interiomarginal arch in the final chamber, those of previous chambers also remaining open into the umbilicus.

Greatest diameter of hypotypes ranges from 0.18 to 0.38 mm.

REMARKS: *Globigerina spiralis* Bolli is distinguished by the globular test and the extremely prominent spire,

the early whorls standing somewhat above the general level of the surface on the spiral side. The somewhat smaller, smooth and thin-walled final chamber is also a characteristic feature.

According to Bolli (1957, p. 70) this species is restricted to the *Globorotalia uncinata* zone of the Lower Lizard Springs (lower Paleocene). In the Gulf and Atlantic coast Paleocene it occurs somewhat higher in the section in the uppermost Paleocene, and no similar forms occur in lower Paleocene samples. It occurs in the Salt Mountain limestone, Aquia, Hornerstown and Vincentown formations.

**TYPES AND OCCURRENCE:** Figured hypotypes (USNM P5121a-e) from the Vincentown formation, along north bluff of Rancoas Creek, 0.3 to 0.5 mile northwest of Vincentown, Burlington County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured hypotype (USNM P5122) from the Salt Mountain limestone, in a limestone sink, ½ mile north of Salt Mountain, in the NW¼ NW¼, Sec. 34, T. 6 N., R. 2 E., Clarke County, Alabama. Collected by H. T. and A. R. Loeblich, Jr.

Figured hypotype (USNM P5338) from the Hornerstown formation, north bank of Shingle Run, a tributary to Crosswicks Creek, 1.0 mile north of New Egypt, Monmouth County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

This species also occurs in the Aquia formation of Virginia.

#### *Globigerina triloculinoides* Plummer

PLATES 40, FIGURES 4a-c; 41, FIGURES 2a-c; 42, FIGURES 2a-c; 43, FIGURES 5a-c; 5a-9c; 45, FIGURES 3a-c; 46, FIGURES 1a-c; 47, FIGURES 2a-c; 52, FIGURES 3-7; 56, FIGURES 8a-c; 62, FIGURES 3a-4c

*Globigerina triloculinoides* PLUMMER, Univ. Texas Bull. 2644, p. 134, pl. 8, figs. 10a-c, 1926.—JENNINGS, Bull. Amer. Paleontol., vol. 23, No. 78, p. 193, pl. 31, fig. 7, 1936.—HOFKER, Rep. McLean Forum. Lab., No. 2, p. 15, pl. 2, 1955.—SHIFFLET, Maryland Dep. Geol., Mines and Water Resources Bull. 3, p. 71, pl. 4, figs. 16, 17, 1948.

*Globigerina pseudotriloba* WHITE, Journ. Paleontol., vol. 2, No. 3, p. 194, pl. 27, fig. 17, 1928.

*Globigerina triangularis* WHITE, Journ. Paleontol., vol. 2, No. 3, p. 195, pl. 28, fig. 1, 1928.

*Globigerina velascoensis* var. *compressa* WHITE (not *Globigerina compressa* Plummer, 1926), Journ. Paleontol., vol. 2, No. 3, p. 196, pl. 28, fig. 3, 1928.

*Globigerina bulloides* d'Orbigny, JENNINGS, Bull. Amer. Paleontol., vol. 23, No. 78, p. 193, pl. 31, fig. 7, 1936.

*Globigerina linaperta* FINLAY, BRONNIMANN, Bull. Amer. Paleontol., vol. 34, p. 164, pl. 2, figs. 7-9, 1952.—BOLLI, U. S. Nat. Mus. Bull. 215, p. 70, pl. 15, figs. 15-17, 1957.

*Globigerina stainforthi* BRONNIMANN, Bull. Amer. Paleontol., vol. 34, p. 171, pl. 3, figs. 10-12, 1952.

*Globigerina finlayi* BRONNIMANN, Bull. Amer. Paleontol., vol. 34, p. 166, pl. 2, figs. 10-12, 1952.

*Globigerina hornibrooki* BRONNIMANN, Bull. Amer. Paleontol., vol. 34, p. 163, pl. 12, figs. 4-6, 1952.

*Globorotalia tortiva* BOLLI (new name for *Globigerina velascoensis* var. *compressa* White, 1928; not *Globigerina compressa* Plummer, 1926), U. S. Nat. Mus. Bull. 215, p. 78 (not pl. 19, figs. 19-21), 1957.

Test free, composed of rapidly enlarging chambers in a low trochospiral arrangement; chambers subglobular,

the two whorls of chambers visible on the flattened spiral side, only the 3 to 3½ chambers of the final whorl visible on the umbilical side, with the final one occupying ¼ to ½ the side; sutures distinct, depressed; wall calcareous, finely perforate, surface prominently reticulate; aperture interiomarginal, umbilical, with a distinct and prominent lip, the aperture in some specimens showing a tendency to become extraumbilical-umbilical.

Hypotypes range from 0.23 to 0.43 mm. in greatest diameter and 0.15 to 0.33 mm. in thickness.

**REMARKS:** *Globigerina triloculinoides* Plummer is characterized by the tripartite appearance of the umbilical side, with the exceptionally large and inflated final chamber and the typical pitted or reticulate surface. The aperture is typically umbilical, but in some specimens extends somewhat more forward, tending to become extraumbilical-umbilical, as is true of occasional specimens in many other species of *Globigerina*.

An examination of a large suite of specimens from a single locality shows considerable variation in minor features, but these variations are obviously within the limits of a single population. For this reason, we consider as synonyms here certain of these variations which have been given distinct names in the past even though they occur together in a single assemblage or are of the same age.

Bolli (1957, p. 70) considered *Globigerina finlayi* Bronnimann a synonym of *G. linaperta* Finlay and *G. hornibrooki* Bronnimann a synonym of *G. triangularis* White. He considered *G. stainforthi* transitional between *G. triloculinoides* Plummer and *G. pseudobulloides* Plummer. *Globigerina stainforthi*, *G. hornibrooki*, *G. finlayi*, *G. triangularis*, and *G. pseudotriloba* White all are here considered synonyms of *G. triloculinoides* Plummer as all have relatively few chambers, rapidly increasing in size, and a coarsely reticulate surface.

*Globigerina linaperta* Finlay is a middle Eocene instead of a Paleocene species, and is characterized by an almost equatorial aperture. The similarity to *G. triloculinoides* Plummer in chamber development and coarsely punctate surface, and the tendency of some specimens of *G. triloculinoides* to develop an extraumbilical aperture, strongly suggest that *G. linaperta* is a descendant of the earlier *G. triloculinoides*. The specimens referred to *G. linaperta* by Bronnimann (1952) from the lower Lizard Springs are typical *G. triloculinoides*, not *linaperta*, and are of Paleocene age.

*Globigerina pseudobulloides* Plummer does not have a coarsely reticulate surface, has more chambers per whorl, a more gradual rate of increase in chamber size and a more definitely extraumbilical aperture.

*Globigerina hornibrooki* Bronnimann is probably a synonym of *G. triangularis* White as was stated by Bolli, but we regard both as synonyms of *G. triloculinoides*. The type specimens of these species show a more gradual increase in chamber size than does the original figure of *G. triloculinoides*, as the type specimens of *G. triangularis* White have 4 chambers in the final

whorl, resulting from less rapid increase in chamber size than in *G. trilocolinoides*. A large suite of topotypes of *G. trilocolinoides* contains specimens with all of these variations and many others. *Globigerina hornibrooki* was defined as differing in having the final chamber smaller than the penultimate one, but the gerontic character of a final chamber of reduced size is common to many species and not of specific importance.

*Globigerina velascoensis* Cushman var. *compressa* White is merely *Globigerina trilocolinoides* Plummer with somewhat flattened final chamber. This varietal name is a homonym of *G. compressa* Plummer, 1926. Bolli (1957, p. 78) renamed this homonym as *Globorotalia tortiva* Bolli, new name, but the specimen he figured is a species distinct from that of White and thus must either be otherwise identified or itself made the basis of another specific name.

**TYPES AND OCCURRENCE:** Figured hypotype (USNM P5814) from the ?lower Danian, zone of *Tylocidaris odumi* Brünnich Nielsen, Hjerm (western quarry), northwestern Denmark. Collected by J. C. Troelsen.

Figured hypotype (USNM P5815) from the Kincaid formation, in a small stream bank on the east side of the road to Lund, 3 miles northwest of Elgin on the Bastrop-Travis County line, 0.5 mile north of the junction with the Austin-Elgin highway, Texas. Collected by A. R. Loeblich, Jr.

Figured topotype (USNM P5816) from the Wills Point formation, shallow ditch at the road corner southeast of the new Corsicana Reservoir, on the road to Mildred, Navarro County, Texas. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5817) from the Mexia clay member of the Wills Point formation, in abandoned pit of the Mexia Brick Works at Mexia, Limestone County, Texas. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5818) from the McBryde limestone member of the Clayton formation, in bed of Rock Creek, 0.8 mile south of junction of Alabama highways 28 and 10, on Alabama highway 10, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5819) from the Matthews Landing marl member of the Porters Creek clay at Naheola Landing on the Tombigbee River, SE¼, Sec. 30, T. 15 N., R. 1 E., 11 miles east of Jachin, Choctaw County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5697) from the Coal Bluff marl member of the Naheola formation in creek bottom, just west of store at Caledonia, about ¼ mile south of center of Sec. 29, T. 11 N., R. 10 E., Wilcox County, Alabama. Collected by F. Stearns MacNeil.

Figured hypotype (USNM P5698) from the Salt Mountain limestone, in a limestone sink, ½ mile north of Salt Mountain, in the NW¼NW¼, Sec. 34, T. 6 N., R. 2 E., Clarke County, Alabama. Collected by H. T. and A. R. Loeblich, Jr.

Figured hypotype (USNM P5699) from the type locality of the Brightseat formation, 1 mile west-southwest of Brightseat and 0.2 mile south of Sheriff Road,

Prince Georges County, Maryland. Collected by A. R. Loeblich, Jr. and Richard A. Page.

Figured hypotype (USNM P5700) from the Aquia formation, 15 to 17 feet above base, west bank of Potomac River, near mouth of Aquia Creek, S. 10° E. of Brent Point, on U. S. Geological Survey Nanjemoy Md.-Va. Quadrangle, 1:62,500, 1913, reprinted 1945. Collected by A. R. Loeblich, Jr., and Richard A. Page.

Figured hypotypes (USNM P5123a-e) from the Vincentown limesand, along north bluff of Rancocas Creek, 0.3 to 0.5 mile northwest of Vincentown, Burlington County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

The species also occurs in the Hornerstown formation, north bank of Shingle Run, a tributary to Crosswicks Creek, 1.0 mile north of New Egypt, Monmouth County, New Jersey.

Lectotype (Columbia Univ. 19882), here designated, of *Globigerina velascoensis* var. *compressa* White from the Velasco formation, Columbus Station on the Tampico-Monterey railroad line, Mexico.

Figured hypotype (USNM P5883) from the Velasco formation, middle bed at road crossing of arroyo halfway between San José de las Rusias and Soto la Marina, Tamaulipas, Mexico. Collected by R. Wright Barker.

#### *Globigerina* species

#### PLATE 50, FIGURES 2a-c

**REMARKS:** A juvenile specimen of a finely spinose *Globigerina* is figured, but it is not certain to which species it should be referred. As compared to the associated species, it is less high spired and has fewer chambers per whorl than does *G. spiralis* Bolli, is much thicker and with fewer chambers per whorl than *Globorotalia perclara*, new species, and has a more bluntly rounded periphery and less oblique sutures on the spiral side than does *Globorotalia convexa* Subbotina. This form is too rare to be described as a distinct species, however.

Figured specimen 0.18 mm. in diameter.

**TYPES AND OCCURRENCE:** Figured specimen (USNM P5849) from the Hornerstown formation, north bank of Shingle Run, a tributary to Crosswicks Creek, 1.0 mile north of New Egypt, Monmouth County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

#### Genus *Globigerinoides* Cushman, 1927

#### *Globigerinoides* daubjergensis (Bronnimann)

PLATES 40, FIGURES 1a-c, 2a-c; 41, FIGURES 9a-c; 42, FIGURES 6a-7c; 43, FIGURES 1a-c; 44, FIGURES 7-8c

*Globigerina daubjergensis* BRONNIMANN, *Ecol. Geol. Helvetiae*, vol. 45 (1952), No. 2, p. 340, text-fig. 1, 1953

Test free, small, trochospiral, high spired; chambers few in number, globular, increasing rapidly in size, forming about two whorls with 3½ to 4 chambers in the final whorl; umbilicus small, commonly open, but may become closed by a somewhat overlapping final chamber; sutures distinct, depressed; wall calcareous,

finely perforate, surface spinose; primary aperture a small high arch, interiomarginal and umbilical in position, secondary apertures tiny along the sutures on the spiral side. Specimens range from 0.15 to 0.35 mm. in greatest diameter.

REMARKS: This species was originally described from the Danian of Jutland, Denmark, and was placed in the genus *Globigerina* d'Orbigny, as the small supplementary apertures of the spiral side were not observed. These openings have since been noted on type Danian specimens by Troelsen (1957), and are here shown in specimens from the Danian of Sweden, as well as from those of the Gulf and Atlantic Coast Paleocene. In his original description Bronnimann (1953, p. 339) stated that the type Danian contains "a small number of characteristic *Globigerina* and *Globorotalia* species, which, with the exception of *Globigerina daubjergensis* n. sp., are known from the Paleocene of Texas . . ." This characteristic species is also quite abundant in both the Kincaid and Wills Point formations of the Midway group in Texas, probably having been overlooked in the past due to its small size. It occurs also in the Pine Barren and McBryde members of the Clayton formation of Alabama, and in the Brightseat formation of Maryland.

TYPES AND OCCURRENCE: The holotype was described from the Danian at Daubjerg, quarry southwest of Stavnsbjerg Farm, Denmark. Originally stated to be deposited in the Cushman Collection, U. S. National Museum, Washington, D. C., but not as yet deposited therein.

Figured hypotype (USNM P5709) from the upper Danian, zone of *Tylocidaris vexilifera* Schlüter, from calcarenite at Östra Torp, Sweden. Collected by J. G. Carlsson.

Figured hypotype (USNM P5710) from the Kincaid formation in a small stream bank on the east side of the road, 3 miles northwest of Elgin, on the secondary road leading to Lund, and lying on the Bastrop-Travis County line, about 0.5 mile north of its junction with the Austin-Elgin highway, Texas. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5711) from the Wills Point formation, 200 feet east of the bridge over Tehuacana Creek in bank of creek, 4 miles north of Mexia on the Mexia-Wortham road, Limestone County, Texas. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5712) from the Mexia clay member of the Wills Point formation, in abandoned pit of Mexia Brick Works at Mexia, Limestone County, Texas. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5713) from the Pine Barren member of the Clayton formation, blue-black micaceous clay in road cut opposite country store, 0.8 mile west of Alabama River Bridge on Alabama Highway 28, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5714) from the McBryde limestone member of the Clayton formation, in bed of Rock Creek, 0.8 mile south of junction of

Alabama Highways 28 and 10, on Highway 10, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotypes (USNM P5715a,b) from the type locality of the Brightseat formation, 1 mile west-southwest of Brightseat and 0.2 mile south of Sheriff Road, Prince Georges County, Maryland. Collected by A. R. Loeblich, Jr., and Richard A. Page.

### Family Globorotaliidae Cushman, 1927

#### Genus Globorotalia Cushman, 1927

##### *Globorotalia acuta* Toulmin

PLATES 47, FIGURES 5a-c; 55, FIGURES 4a-5c; 58, FIGURES 5a-c

*Globorotalia wilcozensis* Cushman and Ponton var. *acuta* TOULMIN, Journ. Paleontol., vol. 15, p. 608, pl. 82, figs. 6-8, 1948.—SHIFFLET, Maryland Dep. Geol., Mines and Water Resources Bull. 3, p. 73, pl. 4, figs. 23a-c, 1948.

*Globorotalia (Truncorotalia) lacerti* Cushman and Renz, HOFKER, Rep. McLean Forum. Lab., No. 2, p. 14, pl. 1, 1955.

Test free, planoconvex, umbilicoconvex, periphery keeled, umbilical shoulder sharply angled and strongly spinose, umbilicus relatively wide and open; chambers angular conical in shape, increasing gradually in size and angularity, all the 2 to 2½ whorls visible on the flat spiral side, only the 4 to 6 chambers of the final whorl visible on the angularly convex umbilical side; sutures distinct and thickened, but flush with the surface, oblique and directed sharply backwards on the spiral side, radial and depressed on the umbilical side; wall calcareous, distinctly and coarsely perforate, surface spinose, with a somewhat sugary appearance especially in the earlier chambers, peripheral margin with a spinose keel and highly ornamented, very sharply angled or even keeled umbilical shoulder; aperture interiomarginal, extraumbilical-umbilical, with a distinctly triangular toothlike lip, earlier apertures remaining open into the wide umbilicus.

Hypotypes range in diameter from 0.20 to 0.55 mm. in diameter and in thickness from 0.13 to 0.28 mm.

REMARKS: This species has in the past been variously referred to as a variety (or subspecies) of *Globorotalia wilcozensis* (by Toulmin, 1941, p. 608) or as a variety of *G. velascoensis* (by Grimsdale, 1951, p. 471). Bolli (1957) regards it as synonymous with *G. velascoensis*, as he stated that a gradation occurs between these forms in the Velasco shale of Mexico. Although both forms do occur in the Velasco, we regard the two species as distinct, for in more northern regions only specimens like the typical *G. acuta* have been observed. This is true of the Salt Mountain limestone of Alabama where *G. acuta* was first described, the Aquia formation of Virginia, and the Vincentown formation of New Jersey; in each region *G. acuta* is abundantly represented, whereas there are no specimens similar to the type of *velascoensis*.

*Globorotalia acuta* Toulmin differs from *G. velascoensis* (Cushman) in being somewhat smaller and in having a less pronounced peripheral keel than does *G. velascoensis*. *Globorotalia acuta* has a more rapid increase in chamber size, with the final chamber commonly occupying ¼ to

$\frac{1}{2}$  of the umbilical side, and the final chamber of *G. velascoensis* comprises  $\frac{1}{4}$  to  $\frac{1}{2}$  of the umbilical side, the ornamentation of the umbilical shoulder is more highly ornamented in *G. velascoensis*, and the sutures of the spiral side are limbate, elevated, and beaded. The sutures of *G. acuta* are flush with the spiral surface.

**TYPES AND OCCURRENCE:** Figured hypotypes (USNM P5141a,b) from the Vincentown formation, north bluff of Rancocas Creek, 0.3 to 0.5 miles north of Vincentown, Burlington County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured hypotype (USNM P5142) from the Salt Mountain limestone, in a limestone sink  $\frac{1}{2}$  mile north of Salt Mountain, in the NW $\frac{1}{4}$  NW $\frac{1}{4}$ , Sec. 34, T. 6 N., R. 2 E., Clarke County, Alabama. Collected by H. T. and A. R. Loeblich, Jr.

The species also occurs in the Velasco formation, middle bed at road crossing of arroyo halfway between San José de las Rusias and Soto la Marina, Tamaulipas, Mexico. Collected by R. Wright Barker.

Figured hypotype (USNM P5865) from the Aquia formation, 10 to 13 feet above the base of the exposed section, west bank of Potomac River, near mouth of Aquia Creek, S. 10° E. of Brent Point on U. S. Geological Survey Nanjemoy Md.-Va. Quadrangle, 1:62,500, 1913, reprinted 1945. Collected by A. R. Loeblich, Jr., and Richard A. Page.

#### *Globorotalia aequa* Cushman and Renz

PLATES 46, FIGURES 7a-8c; 50, FIGURES 6a-c; 55, FIGURES 8a-c(?); 59, FIGURES 6a-c; 60, FIGURES 3a-c; 64, FIGURES 4a-c

*Globorotalia crassata* (Cushman) var. *aequa* CUSHMAN and RENZ, Contr. Cushman Lab. Foram. Res., vol. 18, pt. 1, p. 12, pl. 3, figs. 3a-c, 1942.

Test free, trochospiral, spiral side flat or slightly convex, umbilical side strongly convex, periphery sharply angled with a narrow keel, peripheral outline strongly lobulate; chambers increasing rapidly in size, lunate in spiral view, rhomboidal and truncate in section, sharply angled at the umbilical shoulder around a relatively wide and open umbilicus, lower margin of final chamber commonly constricted against the earlier whorl, the chamber expanding above in width, sutures distinct, gently curved, slightly thickened and beaded on the spiral side, each chamber being attached somewhat below the level of the anterior margin of the preceding one, giving the appearance of a depression at the sutures, sutures radial and constricted on the umbilical side; wall calcareous, finely perforate, keel and sutures on spiral side thickened and nodose, remainder of surface somewhat granular in appearance although final chamber may be somewhat smoother; aperture interiomarginal, extraumbilical-umbilical, in well preserved specimens with a thin and delicate subtriangular lip.

Hypotypes range from 0.30 to 0.40 mm. in diameter.

**REMARKS:** *Globorotalia aequa* differs from *G. rex* Martin in having higher chambers, fewer per whorl,

more lobulate periphery, more angular umbilical shoulder and wider umbilicus, more spinose keel and pustulose surface. The spiral side of *G. rex* is flat and sutures flush, whereas in *G. aequa* the chambers are somewhat imbricated in appearance, and the sutures thickened and nodose.

Rarely, a specimen may show a dwarfed instead of the more usual large and prominent final chamber, such as that shown on plate 55, figure 8. This final chamber somewhat resembles the bullae developed by some orbulinids, in the thin wall, lessened ornamentation and tendency to cover the previous aperture. The aperture of this final chamber is nearly umbilical in position. However, it retains the characteristic surface of the species, and the final chamber is visible on both the spiral and umbilical sides. Typical simple bullae, such as found in *Catapsydrax* are distinctly umbilical in position, completely covering the former aperture and the umbilicus, and commonly lack the ornamentation of the true chambers. The small chamber here shown is thus undoubtedly only a senile development of the specimen and not of generic or specific importance.

**TYPES AND OCCURRENCE:** The hypotype (USNM P5888) figured on plate 55 is questionably referred here. It is from the Vincentown limestone, north bluff of Rancocas Creek, 0.3 to 0.5 mile north of Vincentown, Burlington County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured hypotype (USNM P5889) from the Horners-town formation, north bank of Shingle Run, a tributary to Crosswicks Creek, 1.0 mile north of New Egypt, Monmouth County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured hypotype (USNM P5894) from the Velasco formation, middle bed at road crossing of arroyo halfway between San José de las Rusias and Soto la Marina, Tamaulipas, Mexico. Collected by R. Wright Barker.

Figured hypotype (USNM P5125) from the Aquia formation, 15 to 17 feet above the base of the exposed section, west bank of Potomac River, near mouth of Aquia Creek, S. 10° E. of Brent Point on U. S. Geological Survey Nanjemoy Md.-Va. Quadrangle, 1:62,500, 1913, reprinted 1945.

Figured hypotype (USNM P5863) from the Nanafalia formation, south valley wall of Shoal Creek, 5.5 miles southeast of Camden, along the Camden-Fatama road, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotypes (USNM P5864a, b) from the Coal Bluff marl member of the Naheola formation, in creek bottom, just west of store at Caledonia, about  $\frac{1}{2}$  mile south of the center of Sec. 29, T. 11 N., R. 10 E., Wilcox County, Alabama. Collected by F. Stearns MacNeil.

The species was originally described from the Soldado formation (Paleocene) of Trinidad, B. W. I.

*Globorotalia angulata* (White)

PLATES 45, FIGURES 7 a-c; 48, FIGURES 2a-c; 50, FIGURES 4a-c; 55, FIGURES 2, 6, 7; 58, FIGURES 2a-c; 64, FIGURES 5a-c

*Globigerina angulata* WHITE, Journ. Paleontol., vol. 2, p. 191, pl. 27, figs. 13a-c, 1928.

*Globorotalia wilcozensis* Cushman and Ponton, SHIFFLETT, Maryland Dep. Geol., Mines and Water Resources Bull. 3, p. 73, pl. 4, figs. 20-22, 1948.

Test free, trochospirally coiled, peripheral margin truncate and sharply angled, peripheral outline lobulate, biconvex to umbilicoconvex, umbilicus small, rounded and deep; chambers lunate in spiral view, cuneate in umbilical view, angular rhomboid in edge view, umbilical shoulder acutely angled, 4 to 4½ chambers per whorl, increasing rapidly in size; sutures distinct, curved and oblique on the spiral side, strongly depressed, straight and radial on the umbilical side and very strongly incised in the peripheral area; wall calcareous, finely perforate, surface smooth to lightly spinose on the spiral side, more prominently spinose on the umbilical side, and at the peripheral margins; aperture interiomarginal, extraumbilical-umbilical, a high arch directed somewhat forward, with a narrow bordering lip preserved in some specimens.

Hypotypes range in diameter from 0.30 to 0.45 mm., and in thickness from 0.20 to 0.28 mm.

REMARKS: *Globorotalia angulata* (White) differs from *G. rez* Martin in having a more angled and elevated umbilical shoulder, the chambers are slightly inflated on the spiral side, with sutures depressed, and have an imbricated appearance, the posterior margin of each succeeding chamber attaching below the anterior margin of that preceding, whereas in *G. rez* the spiral chamber surface forms a plane.

TYPES AND OCCURRENCE: Figured hypotypes (USNM P5127a-c) from the Vincentown limesand, north bluff of Rancocas Creek, 0.3 to 0.5 miles north of Vincentown, Burlington County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured hypotype (USNM P5126) from the Salt Mountain limestone, in a limestone sink ½ mile north of Salt Mountain in the NW¼NW¼, Sec. 34, T. 6 N., R. 2 E., Clarke County, Alabama. Collected by H. T. and A. R. Loeblich, Jr.

Figured hypotype (USNM P5859) from the Aquia formation, 15 to 17 feet above the base of the exposure, near mouth of Aquia Creek, S. 10° E. of Brent Point on U. S. Geological Survey Nanjemoy Md.-Va. Quadrangle, 1:62,500, 1913, reprinted 1945. Collected by A. R. Loeblich, Jr., and Richard A. Page.

Figured hypotype (USNM P5891) from the Velasco formation, middle bed at road crossing of arroyo of, halfway between San José de las Rusias and Soto la Marina, Tamaulipas, Mexico. Collected by R. Wright Barker.

Figured hypotype (USNM P5892) from the Matthews Landing marl member of the Porters Creek clay at Naheola Landing on the Tombigbee River, SE¼, Sec. 30, T. 15 N., R. 1 E., 11 miles east of Jachin, Choctaw County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5893) from the Horners-town formation, north bank of Shingle Run, a tributary to Crosswicks Creek, 1.0 mile north of New Egypt, Monmouth County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

*Globorotalia apantesma* Loeblich and Tappan, new species

PLATES 48, FIGURES 1a-c; 55, FIGURES 1a-c; 58, FIGURES 4a-c; 59, FIGURES 1a-c

*Globorotalia cf. angulata* (White) SHIFFLETT, Maryland Dep. Geol., Mines and Water Resources Bull. 3, p. 72, pl. 4, figs. 18a-c, 1948.

Test free, trochospiral, planoconvex, umbilicoconvex, with rather wide, deep and open umbilicus, periphery subacute, peripheral outline lobulate; chambers hemispherical, flattened to gently convex and appearing lunate in side view from the spiral side, strongly inflated to subangular on the umbilical side, 4 to 5 in the final whorl, commonly somewhat obliquely overlapping earlier chambers, the forward margin of each chamber protruding slightly above the general level of the spiral side, the posterior margin of the succeeding chamber beginning at a slightly lower level; sutures distinct, strongly curved and slightly depressed on the spiral side, radial and strongly depressed on the umbilical side, wall calcareous, rather coarsely perforate, surface spinose, most strongly on the umbilical side; aperture interiomarginal, extraumbilical-umbilical, a broad arched opening, with a narrow bordering lip present in well preserved specimens.

Hypotypes range from 0.23 to 0.45 mm. in diameter and from 0.15 to 0.33 mm. in thickness.

REMARKS: *Globorotalia apantesma*, new species, differs from *G. acuta* Toulmin in lacking a peripheral keel, in having a spinose surface, less angular chambers, more convex spiral side, and less ornamented umbilical shoulder.

*Globorotalia angulata* (White) differs in being larger, in having fewer chambers and more rapid increase in chamber size and the chambers are more angular in spiral view, more inflated in umbilical view, with a more truncate periphery and a more finely spinose surface.

The specific name is from the Greek *apantesma*, a plucked flower.

TYPES AND OCCURRENCE: Holotype (USNM P5860) and figured paratype (USNM P5868) from the Aquia formation, 10 to 13 feet above the base of the exposed section, west bank of Potomac River, near mouth of Aquia Creek, S. 10° E. of Brent Point on U. S. Geological Survey Nanjemoy Md.-Va. Quadrangle, 1:62,500, 1913, reprinted 1945. Collected by A. R. Loeblich, Jr., and Richard A. Page.

Figured paratype (USNM P5861) from the Vincentown formation, north bluff of Rancocas Creek, 0.3 to 0.5 miles north of Vincentown, Burlington Co., New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured paratype (USNM P5862) from the Salt

Mountain limestone, in a limestone sink,  $\frac{1}{2}$  mile north of Salt Mountain in the NW $\frac{1}{4}$ NW $\frac{1}{4}$ , Sec. 34, T. 6 N., R. 2 E., Clarke Co., Alabama. Collected by H. T. and A. R. Loeblich, Jr.

*Globorotalia compressa* (Plummer)

PLATES 40, FIGURES 5a-c; 41, FIGURES 5a-c; 42, FIGURES 5a-c; 44, FIGURES 9a-10c

*Globigerina compressa* PLUMMER, Univ. Texas Bull. 2644, p. 135, pl. 8, figs. 11a-c, 1926.

*Globorotalia ehrenbergi* BOLLI, U. S. Nat. Mus. Bull. 215, p. 77, pl. 20, figs. 13-20, 1957.

Test free, trochospiral, compressed, umbilical side with small deep umbilicus, periphery subacute, peripheral outline lobulate; chambers moderately inflated, more so on the umbilical side, enlarging rapidly in size as added, of nearly equal breadth and height, arranged in about 2 whorls, commonly 5 occur in the final whorl; sutures distinct, gently curved, slightly depressed; wall calcareous, distinctly perforate, surface smooth; aperture interiomarginal, extraumbilical-umbilical, an arched opening extending nearly to the periphery, and bordered above with a narrow lip.

Hypotypes range in diameter from 0.28 to 0.38 mm.

REMARKS: This species has been misinterpreted by some workers. Bronnimann (1952, p. 25, pl. 12, figs. 19-24) referred to *G. compressa* specimens with a more angular or keeled periphery, rapid increase in chamber size, relatively large final chamber, and larger test; these latter forms are here referred to *Globorotalia elongata* Glaessner. The holotype of *Globorotalia ehrenbergi* Bolli is identical in appearance to metatypes of *G. compressa* Plummer, and this specific name is therefore considered a synonym.

Typical *G. compressa* (as shown by metatypes and topotypes) is very similar to *Globigerina pseudobulloides* Plummer, differing in being smaller and with a somewhat more angular peripheral margin (compressed) and smooth, very finely perforate wall instead of the more coarsely perforate and pitted wall of *G. pseudobulloides*.

*Globorotalia imitata* Subbotina is also similar to the present species but has a rounded rather than subacute periphery, and a more flattened spiral side, more curved sutures and lower chambers.

TYPES AND OCCURRENCE: Figured hypotype (USNM P5716) from the Danian calcarenite at Östratorp, Skåne, Sweden. Collected by J. C. Troelsen.

Figured hypotypes (USNM P5717a,b) from the Wills Point formation, in road cut near top of hill on the Corsicana-Navarro road just south of the junction with the Mildred road, Navarro County, Texas. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5718) from the McBryde limestone member of the Clayton formation, in bed of Rock Creek, 0.8 mile south of junction of Alabama Highways 28 and 10, on Highway 10, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5719) from the type locality of the Brightseat formation, 1 mile west-south-

west of Brightseat and 0.2 mile south of Sheriff Road, Prince Georges County, Maryland. Collected by A. R. Loeblich, Jr., and Richard A. Page.

*Globorotalia convexa* Subbotina

PLATES 43, FIGURES 4a-c; 50, FIGURES 7a-c; 53, FIGURES 6a-8c; 57, FIGURES 5a-6c; 61, FIGURES 4a-c; 63, FIGURES 4a-c

*Globorotalia convexa* SUBBOTINA, Trudy Vses. Neft. Naukno-Issledov. Geol.-Razved. Inst., new ser., vol. 76, p. 209, pl. 17, figs. 2a-3c, 1953.

Test free, ovate in outline, trochospirally coiled, inflated, peripheral margin rounded, peripheral outline slightly lobulate; chambers gradually enlarging, all whorls visible on the flattened spiral side, only the 4 to 6 chambers of the final whorl visible around the nearly closed umbilicus on the umbilical side; sutures somewhat indistinct, strongly curved backwards on the spiral side, radial on the umbilical side; wall calcareous, perforate, entire surface spinose; aperture interiomarginal, extraumbilical-umbilical, a low arched opening extending about halfway to the periphery, with a narrow lip above.

Hypotypes range in greatest diameter from 0.23 to 0.30 mm. and in thickness from 0.13 to 0.23 mm.

REMARKS: *Globorotalia convexa* Subbotina is similar to *Globigerina mckannai* White in its surface texture and number of chambers per whorl, but differs in the smaller size, more strongly curved but somewhat obscure and less incised sutures, more broadly rounded periphery, and nearly closed umbilicus.

It differs from *Globorotalia albeari* Cushman and Bermudez in being smaller, in having fewer chambers per whorl, a more rounded periphery, less distinct sutures, flatter spiral side, and more spinose surface.

It is similar in appearance to *Globorotalia brodermanni* Cushman and Bermudez from the lower Eocene Capdevila formation of Cuba, but differs in being only about  $\frac{1}{2}$  as large and in having a more closed umbilicus, and a lower and much smaller apertural opening. The present species is probably ancestral to the lower Eocene species.

TYPES AND OCCURRENCE: Figured hypotypes (USNM P5129a-c) from the Vincentown formation, north bluff of Rancocas Creek, 0.3 to 0.5 miles north of Vincentown, Burlington County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured hypotype (USNM P5845) from the Hornerstown formation, north bank of Shingle Run, a tributary to Crosswicks Creek, 1.0 mile north of New Egypt, Monmouth County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured hypotypes (USNM P5846a, b) from the Aquia formation, 14-16 feet above base of exposure, west bank of Potomac River, near mouth of Aquia Creek, S. 10° E. of Brent Point on U. S. Geological Survey Nanjemoy Md.-Va. Quadrangle, 1:62,500, 1913, reprinted 1945. Collected by A. R. Loeblich, Jr., and Richard A. Page.

Figured hypotype (USNM P5847) from the Salt



Mountain limestone, in a limestone sink, ½ mile north of Salt Mountain, in the NW¼ NW¼, Sec. 34, T. 6 N., R. 2 E., Clarke County, Alabama, Collected by H. T. and A. R. Loeblich, Jr.

Figured hypotype (USNM P5848) from the Nanafalia formation, basal 6 feet of formation just above Midway group, road cut 0.2 mile east of the Turkey Creek bridge, 1.2 miles east of Kimbrough Station, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5885) from the Velasco formation, middle bed at road crossing of arroyo halfway between San José de las Rusias and Soto la Marina, Tamaulipas, Mexico. Collected by R. Wright Barker.

It was originally described from the "lower Eocene" of Russia, where it occurred in the *Globorotalia velascoensis* zone, a zone here considered to be of Paleocene age.

#### *Globorotalia elongata* Glaessner

PLATES 45, FIGURES 5a-c; 46, FIGURES 5a-c; 48, FIGURES 5a-c; 49, FIGURES 7a-c; 54, FIGURES 1a-5c; 59, FIGURES 4a-c; 60, FIGURES 9a-c; 63, FIGURES 2a-c.

*Globorotalia pseudocitula* Glaessner var. *elongata* GLAESSNER, Studies in Micropaleontol., Univ. Moscow Lab. Paleontol., vol. 1, fasc. 1, p. 33, text-figs. 3d-f, 1937.

*Globorotalia elongata* Glaessner, BOLLÉ, U. S. Nat. Mus. Bull. 215, p. 77, pl. 20, figs. 11-13, 1957.

*Globorotalia compressa* (Plummer) TOULMIN, Journ. Paleontol., vol. 15, No. 6, p. 607, pl. 82, figs. 1, 2, 1941.

Test free, biconvex but compressed, trochospirally coiled, somewhat elongated, peripheral margin rounded to subacute, peripheral outline lobulate; all chambers of the 2 whorls visible on the spiral side, early coils somewhat depressed, only the 4 to 5 chambers of the final whorl visible on the umbilical side, which has a relatively wide and open umbilicus, chambers of nearly equal breadth and height, increasing rapidly in size, final chamber comprising about two-fifths of the entire test; sutures distinct, depressed, gently curved; wall calcareous, finely perforate, surface smooth; aperture interiomarginal, extraumbilical-umbilical, extending to the periphery and may even extend slightly onto the spiral side, with a distinct lip, portions of earlier lips remaining visible around the umbilicus.

Hypotypes range in greatest diameter from 0.20 to 0.55 mm., and in thickness from 0.08 to 0.23 mm.

REMARKS: *Globorotalia elongata* differs from *G. pseudomenardi* Bolli in lacking the peripheral keel and thickened sutures and in having a more incised spiral suture.

TYPES AND OCCURRENCE: Figured hypotype (USNM P5813) from the Matthews Landing marl member of the Porters Creek clay, Naheola Landing, Tombigbee River, SE¼, Sec. 30, T. 15 N., R. 1 E., 11 miles east of Jachin, Choctaw County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5692) from the Coal Bluff marl member of the Naheola formation in creek bottom, just west of store at Caledonia, about ¼ mile

south of center of Sec. 29, T. 11 N., R. 10 E., Wilcox County, Alabama. Collected by F. Stearns MacNeil.

Figured hypotype (USNM P5693) from the Salt Mountain limestone, in a limestone sink, ¼ mile north of Salt Mountain, in the NW¼NW¼, Sec. 34, T. 6 N., R. 2 E., Clarke County, Alabama. Collected by H. T. and A. R. Loeblich, Jr.

Figured hypotype (USNM P5694) from the *Ostrea thirsae* beds of the Nanafalia formation, 56 feet above the Midway contact, in road cut 1.2 miles east of Kimbrough Station, and 0.2 mile east of the Turkey Creek bridge, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5695) from the Aquia formation, 42 feet above the base of the exposure, west bank of Potomac River, near mouth of Aquia Creek, S. 10° E. of Brent Point, on U. S. Geol. Survey Nanjemoy Md.-Va. quadrangle, 1:62,500, 1913, reprinted 1945. Collected by A. R. Loeblich, Jr., and Richard A. Page.

Figured hypotype (USNM P5697) from the Horners-town formation, north bank of Shingle Run, a tributary to Crosswicks Creek, 1.0 mile north of New Egypt, Monmouth County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured hypotypes (USNM P5133a-e) from the Vincentown limesand, along north bluff of Rancocas Creek, 0.3 to 0.5 mile northwest of Vincentown, Burlington County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured hypotype (USNM P5882) from the Velasco formation, middle bed at road crossing of arroyo halfway between San José de las Rusias and Soto la Marina, Tamaulipas, Mexico. Collected by R. Wright Barker.

#### *Globorotalia esnaensis* (Le Roy)

PLATES 57, FIGURES 7a-c(?); 61, FIGURES 1a-2c, 9a-c

*Globigerina esnaensis* LE ROY, Geol. Soc. Amer., Mem. 54, p. 31, pl. 6, figs. 8-10, 1953.

Test free, small, trochospiral, inflated, spiral side flattened, umbilical side convex, umbilicus small, periphery broadly rounded, peripheral outline lobulate; chambers increasing rapidly in size as added, four in the final whorl with final chamber occupying about one-third of the umbilical side; sutures distinct, depressed, radial; wall calcareous, finely perforate, surface finely spinose; aperture an interiomarginal arch tending to extend somewhat to an extraumbilical position.

Hypotypes range in diameter from 0.25 to 0.38 mm.

REMARKS: The specimens here figured are similar to the holotype of *Globorotalia esnaensis* (Le Roy) in all respects, except that they are about half its size. As various other species also appear somewhat smaller in the strata here studied than elsewhere, the specimens are regarded as conspecific. The present species is also very similar to *G. wilcoxensis* Cushman and Ponton, but the latter is almost truncate and the sutures are curved and oblique on the spiral side.

Because of the extraumbilical position of the aperture, the species is here regarded as a *Globorotalia*.

The specimen here figured from the Aquia formation is somewhat questionably referred to this species, as the early spire is more elevated than is usual in this species. Other specimens from the Aquia are quite typical, however, and this specimen is regarded as atypical.

**TYPES AND OCCURRENCE:** Figured hypotypes (USNM P5876a,b) from the Nanafalia formation, basal six feet of the formation, in road cut 0.2 miles east of Turkey Creek bridge and 1.2 miles east of Kimbrough Station, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5877) from the upper 25 feet of the Nanafalia formation exposed in the road cut at the above locality.

Figured hypotype (USNM P5878) from the Aquia formation, 15 to 17 feet above the base of the exposed section, west bank of Potomac River, near mouth of Aquia Creek S. 10° E. of Brent Point on U. S. Geological Survey Nanjemoy Md.-Va. Quadrangle, 1:62,500, 1913, reprinted 1945. Collected by A. R. Loeblich, Jr., and Richard A. Page.

*Globorotalia hispidicaris* Loeblich and Tappan, new species

PLATE 58, FIGURES 1a-c

Test free, of medium size, trochospiral, spiral side gently convex, umbilical side inflated, periphery angularly truncate, peripheral outline gently lobulate; chambers increasing slowly in size, 5 per whorl in early stages, final whorl with 6 to 7 chambers; sutures distinct, slightly depressed, curved and oblique on the spiral side, more deeply depressed, straight and radial around the small umbilicus on the umbilical side; wall calcareous, finely perforate, surface spinose throughout, although final one or two chambers may be less prominently spinose, distinctly spinose at the peripheral angle, presenting a keel-like appearance; aperture a low interiomarginal, extraumbilical-umbilical arch extending to the periphery.

Holotype 0.35 mm. in diameter.

**REMARKS:** This species resembles *Globorotalia conico-truncata* Subbotina from the Russian Danian(?) in the numerous chambers per whorl, truncated spiral side, and the angular-truncate periphery. The present species is smaller and has a prominently spinose surface.

It differs from *Globigerina mekannai* White in being less thickened and more nearly keeled, in having more chambers per whorl, more oblique sutures on the spiral side, and a truncate rather than rounded periphery.

*Globorotalia apantesma*, new species, has fewer chambers per whorl, a less truncate periphery and the chambers slope gradually from the peripheral keel to the umbilical shoulder. The wall surface is also less prominently spinose.

The specific name is from the Latin *hispidus*, bristly, prickly, and *cidaris*, a diadem or tiara, referring to the general appearance of the species.

**TYPES AND OCCURRENCE:** Holotype (USNM P5875) from the Aquia formation, 15 to 17 feet above the base of the exposure, west bank of Potomac River near mouth of Aquia Creek, S. 10° E. of Brent Point on U. S. Geological Survey Nanjemoy Md.-Va. Quadrangle, 1:62,500, 1913, reprinted 1945. Collected by A. R. Loeblich, Jr., and Richard A. Page.

*Globorotalia imitata* Subbotina

PLATES 44, FIGURES 3a-c; 45, FIGURES 6a-c; 54, FIGURES 8a-9c; 59, FIGURES 5a-c; 63, FIGURES 3a-c

*Globorotalia imitata* SUBBOTINA, Trudy Vses. Nauchno-Issledov. Geol.-Razved. Inst., new ser., vol. 76, p. 206, pl. 16, figs. 14-16, 1953.

Test free, tiny, spiral side flattened to gently convex, peripheral margin rounded, peripheral outline lobulate; chambers moderately inflated, ovate, increasing gradually in size and arranged in a low trochospiral coil of about 2 volutions, 4 to 5 in the final whorl; sutures distinct, slightly depressed, gently curved; wall calcareous, finely perforate, surface smooth; aperture interiomarginal, extraumbilical-umbilical, a low arch, bordered by a narrow, protruding lip.

Hypotypes range from 0.15 to 0.25 mm. in diameter, and from 0.09 to 0.13 mm. in thickness.

**REMARKS:** Originally described from strata of Danian age in Russia, this species occurs in beds of equivalent age in Texas (Wills Point formation), but also ranges somewhat higher, occurring also in the Matthews Landing marl member of the Porters Creek clay of Alabama, in the Vincentown formation of New Jersey and the Aquia formation of Virginia.

It somewhat resembles *Globorotalia compressa* (Plummer) in general appearance, but has a less acute periphery which is rounded to almost truncate, an almost flattened spiral side, more curved sutures and lower chambers.

**TYPES AND OCCURRENCE:** Figured hypotype (USNM P5688) from the Wills Point formation (Mexia clay member) in abandoned pit of the Mexia Brick Works at Mexia, Limestone County, Texas. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5689) from the Matthews Landing marl member of the Porters Creek clay, at Naheola Landing, Tombigbee River, SE¼, Sec. 30, T. 15 N., R. 1 E., 11 miles east of Jachin, Choctaw County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5131 a, b) from the Vincentown limesand, along north bluff of Rancocas Creek 0.3 to 0.5 mile northwest of Vincentown, Burlington County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured hypotype (USNM P5691) from the Aquia formation, 15 to 17 feet above the base of the exposure, west bank of Potomac River, near mouth of Aquia Creek, S. 10° E. of Brent Point, on U. S. Geological Survey Nanjemoy, Md.-Va. Quadrangle, 1:62,500, 1913, reprinted 1945. Collected by A. R. Loeblich, Jr., and Richard A. Page.

Figured hypotype (USNM P5886) from the Velasco

formation, middle bed at road crossing of arroyo halfway between San José de las Rusias and Soto la Marina, Tamaulipas, Mexico. Collected by R. Wright Barker.

The species also occurs in the *Ostrae thirsae* beds of the Nanafalia formation in a road cut 1.2 miles east of Kimbrough Station and 0.2 mile east of the Turkey Creek bridge, Wilcox County, Alabama.

*Globorotalia irrorata* Loeblich and Tappan, new species

PLATES 46, FIGURES 2a-c; 61, FIGURES 5a-c

Test free, small, trochospiral, spiral surface somewhat flattened, umbilical surface inflated, umbilicus small and deep, periphery broadly rounded, peripheral outline gently lobulate; chambers increasing gradually in size, 4 to 5 per whorl; sutures depressed, oblique on the spiral side, radial on umbilical side; wall calcareous, finely perforate, surface covered with short blunt spines; aperture a low interiomarginal, extraumbilical-umbilical arch.

Holotype 0.26 mm. in diameter.

REMARKS: *Globorotalia irrorata*, new species, differs from *Acarinina intermedia* Subbotina in having lower chambers, with less rapid increase in thickness. It differs from *Globigerina soldadoensis* Bronnmann in having a more flattened spiral side, lower chambers, radial instead of oblique sutures on the umbilical side, and a lower, and more extraumbilical aperture.

*Globorotalia convexa* differs from the present species in having broader and lower chambers, more oblique sutures, and a less broadly rounded periphery.

The specific name is from the Latin, *irroratus*, bedewed, covered with granules, and refers to the hirsute surface.

TYPES AND OCCURRENCE: Holotype (USNM P5872) from the Nanafalia formation, south valley wall of Shoal Creek, 5.5 miles southeast of Camden, along the Camden-Fatama road, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Figured paratype (USNM P5873) from the Coal Bluff marl member of the Naheola formation, in creek bottom just west of store at Caledonia, about ¼ mile south of the center of Sec. 29, T. 11 N., R. 10 E., Wilcox County, Alabama. Collected by F. Stearns MacNeil.

*Globorotalia oclusa* Loeblich and Tappan, new species

PLATES 55, FIGURES 3a-c; 64, FIGURES 3a-c

Test free, of medium size, trochospiral, spiral side flat, umbilical side convex, with a very small and deep umbilicus, periphery keeled, peripheral outline entire to slightly lobulate; chambers gradually increasing in size, 4 to 5, rarely 6, in the final whorl, of greatest thickness at the umbilical shoulder immediately adjacent to the narrow umbilicus, umbilical shoulder subacutely rounded; sutures distinct, curved and oblique, thickened and flush to slightly elevated on the spiral side, radial and moderately depressed on the umbilical side; wall calcareous, finely perforate, surface smooth except for the thickened sutures on the spiral side and the peripheral keel which may be marginally nodose to

hirsute, umbilical side with a somewhat granular appearance, particularly in the early region of the final whorl; aperture an interiomarginal, extraumbilical-umbilical arch with a distinct lip above.

Greatest diameter of holotype 0.45 mm.

REMARKS: *Globorotalia oclusa*, new species, differs from *G. velascoensis* (Cushman) and *G. acuta* Toulmin in being smaller, of less thickness, and in having a small, almost closed umbilicus in place of the wide umbilicus and sharply angled, highly ornamented umbilical shoulder. It also differs from *G. velascoensis* in having fewer chambers per whorl and from *G. acuta* in having elevated sutures on the spiral side.

It differs from *G. crater* Finlay in having a more narrow umbilicus and a less elevated umbilical side.

The specific name is from the Latin *occlusus*, shut up, closed, and refers to the narrow umbilicus.

TYPES AND OCCURRENCE: Holotype (USNM P5874) from the Velasco formation, middle bed at road crossing of arroyo halfway between San José de las Rusias and Soto la Marina, Tamaulipas, Mexico. Collected by R. Wright Barker.

Figured paratype (USNM P5866) from the Vincentown formation, north bluff of Rancoas Creek, 0.3 to 0.5 miles northwest of Vincentown, Burlington County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

This species also occurs in the Salt Mountain limestone of Alabama and the Aquia formation of Virginia.

*Globorotalia perlara* Loeblich and Tappan, new species

PLATES 40, FIGURES 7a-c; 41, FIGURES 8a-c; 42, FIGURES 4a-c; 45, FIGURES 11a-c; 46, FIGURES 3a-c; 47, FIGURES 6a-c; 50, FIGURES 1a-c; 54, FIGURES 6a-7c; 57, FIGURES 3a-4c; 60, FIGURES 5a-c

*Globigerina* cf. *pseudobulloides* Plummer, SHIFFLET, Maryland Dep. Geol., Mines and Water Resources Bull. 3, p. 71, pl. 4, figs. 14, 15, 1948.

Test free, trochospiral, sides flattened, umbilicus small, peripheral margin broadly rounded, peripheral outline lobulate; 5 to 6 chambers in the final whorl, increasing gradually in size as added, rounded to ovate in shape, or may somewhat overhang the preceding suture, of somewhat greater breadth than height on the spiral side, and commonly somewhat excavated near the spiral suture, elevated near the periphery; sutures distinct, depressed, curved back at the periphery on the spiral side, radial on the umbilical side; wall calcareous, finely perforate, surface smooth to finely hispid on the spiral side, distinctly spinose on the umbilical side; aperture a small, interiomarginal, extraumbilical-umbilical arch.

Holotype 0.26 mm. in diameter.

REMARKS: The specimens from the Aquia formation of Aquia Creek, Virginia, referred by Shifflet (1948) to *Globigerina* cf. *pseudobulloides* Plummer, belong to the present species. It differs from *G. pseudobulloides* (which is here considered also a *Globorotalia*) in the much smaller size, lower chambers, which increase

more slowly in size, and the very prominently spinose umbilical side.

*Globorotalia reissi*, new species, is similar in size, but has a more convex spiral side, and a nearly smooth surface.

**TYPES AND OCCURRENCE:** Holotype (USNM P5356) from the Brightseat formation, 1 mile west-southwest of Brightseat and 0.2 mile south of Sheriff Road, Prince Georges County, Maryland. Collected by A. R. Loeblich, Jr., and Richard A. Page.

Figured paratype (USNM P5821) from the Pine Barren member of the Clayton formation, road cut opposite small country store, 0.8 mile west of the Alabama River Bridge on Alabama state highway 28, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Figured paratype (USNM P5822) from the McBryde limestone member of the Clayton formation, in bed of Rock Creek, 0.8 mile south of junction of Alabama state highways 28 and 10, on highway 10, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Figured paratype (USNM P5823) from the Matthews Landing marl member of the Porters Creek clay, Naheola Landing, Tombigbee River, SE $\frac{1}{4}$ , Sec. 30, T. 15 N., R. 1 E., 11 miles east of Jachin, Choctaw County, Alabama. Collected by A. R. Loeblich, Jr.

Figured paratype (USNM P5824) from the Coal Bluff marl member of the Naheola formation in creek bottom, just west of store at Caledonia, about  $\frac{1}{4}$  mile south of center of Sec. 29, T. 11 N., R. 10 E., Wilcox County, Alabama. Collected by F. Stearns MacNeill.

Figured paratype (USNM P5825) from the Horners-town formation, north bank of Shingle Run, a tributary to Crosswicks Creek, 1.0 mile north of New Egypt, Monmouth County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured paratypes (USNM P5135a, b) from the Vincentown formation, along north bluff of Rancocas Creek 0.3 to 0.5 miles northwest of Vincentown, Burlington County, New Jersey. Collected by A. R. Loeblich, Jr. and Norman Sohl.

Figured paratypes (USNM P5826a, b) from the Aquia formation, 6 to 9 feet above the base of the exposed section, west bank of Potomac River, near mouth of Aquia Creek, S. 10° E. of Brent Point, on U. S. Geological Survey Nanjemoy, Md.-Va. Quadrangle, 1:62,500, 1913, reprinted 1945. Collected by A. R. Loeblich, Jr., and Richard A. Page.

Figured paratype (USNM P5827) from the Nanafalia formation, south valley wall of Shoal Creek, 5.5 miles southeast of Camden, along Camden-Fatama road, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Figured paratype (USNM P5828) from the Salt Mountain limestone, in a limestone sink,  $\frac{1}{2}$  mile north of Salt Mountain, in the NW $\frac{1}{4}$ NW $\frac{1}{4}$ , Sec. 34, T. 6 N., R. 2 E., Clarke County, Alabama. Collected by H. T. and A. R. Loeblich, Jr.

#### *Globorotalia pseudobulloides* (Plummer)

PLATES 40, FIGURES 3a-c, 9a-c; 41, FIGURES 1a-c; 42, FIGURES 3a-c; 43, FIGURES 3a-4c; 44, FIGURES 4-6c; 45, FIGURES 1a-2c; 46, FIGURES 6a-c.

*Globigerina pseudo-bulloides* PLUMMER, Univ. Texas Bull. 2644, p. 133, pl. 8, figs. 9a-c, 1926.

Test free, medium sized, low trochospiral, coil of about 2 $\frac{1}{2}$  volutions, umbilical side with small deep umbilicus; chambers subglobular and inflated, increasing rapidly in size, 5 to 7 in the final whorl, most commonly 5; sutures distinctly constricted; wall calcareous, distinctly perforate and very finely pitted, but not spinose; aperture extraumbilical-umbilical, interiomarginal, a rounded arch bordered above by a narrow lip.

Hypotypes range from 0.18 to 0.50 mm. in diameter.

**REMARKS:** *Globorotalia pseudobulloides* differs from *G. varianta* (Subbotina) in having a more coarsely perforate and finely pitted wall which may give the appearance of being reticulate, but does not have the finely spinose surface of the associated *G. varianta*.

**TYPES AND OCCURRENCE:** Figured hypotype (USNM P5720) from the lower Danian, zone of *Tylocidaris odumii*, bryozoan limestone, filling cavities in underlying calcilutite (*Cerithium* limestone with *Cerithium baltica*) Højersup, Stevns Klint, Denmark. Collected by J. C. Troelsen.

Figured hypotypes (USNM P5721a,b) from the Kincaid formation, in a small stream bank on the east side of the road to Lund, 3 miles northwest of Elgin on the Bastrop-Travis county line, 0.5 mile north of the junction with the Austin-Elgin highway, Texas. Collected by A. R. Loeblich, Jr.

Figured hypotypes (USNM P5722a,b) from the Mexia clay member of the Wills Point formation, in abandoned pit of Mexia Brick Works at Mexia, Limestone County, Texas. Collected by A. R. Loeblich, Jr.

Figured topotype (USNM P5723) from the Wills Point formation, shallow ditch at road corner southeast of the new Corsicana Reservoir, on the road to Mildred, Navarro County, Texas. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5724) from the Pine Barren member of the Clayton formation, blue black micaceous clay exposed in road cut opposite small country store on Alabama highway 28, 0.8 mile west of the Alabama River bridge, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5725) from the McBryde limestone member of the Clayton formation, in bed of Rock Creek, 0.8 mile south of junction of Alabama highways 28 and 10, on highway 10, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotypes (USNM P5726a,b) from the Matthews Landing marl member of the Porters Creek clay, at Naheola Landing, Tombigbee River, SE $\frac{1}{4}$ , Sec. 30, T. 15 N., R. 1 E., 11 miles east of Jachin, Choctaw County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5727) from the Coal Bluff marl member of the Naheola formation in creek bottom, just west of store at Caledonia, about ¼ mile south of center of Sec. 29, T. 11 N., R. 10 E., Wilcox County, Alabama. Collected by F. Stearns MacNeil.

Figured hypotype (USNM P5728) from the type locality of the Brightseat formation, 1 mile west-southwest of Brightseat and 0.2 mile south of Sheriff Road, Prince Georges County, Maryland. Collected by A. R. Loeblich, Jr., and Richard A. Page.

*Globorotalia pseudomenardii* Bolli

PLATES 45, FIGURES 10a-c; 47, FIGURES 4a-c; 49, FIGURES 6a-c; 54, FIGURES 10a-13c; 59, FIGURES 3a-c; 60, FIGURES 8a-c; 63, FIGURES 1a-c

*Globorotalia pseudomenardii* BOLLI, U. S. Nat. Mus. Bull. 215, p. 77, pl. 20, figs. 14-17, 1957.

*Globorotalia membranacea* (Ehrenberg) TOULMIN, Journ. Paleontol., vol. 15, No. 6, p. 608, pl. 82, figs. 4, 5, 1941.

*Globorotalia* cf. *membranacea* (Ehrenberg) HOFKER, Rep. McLean Forum. Lab., No. 2, p. 14, pl. 4, 1955.

Test free, biconvex but compressed, trochospirally coiled, periphery with a narrow but distinct keel; all chambers of the 2½ whorls visible on the gently but regularly convex spiral side, low and broad and curved backwards at the periphery, only the 5 to 5½ chambers of the final whorl visible on the umbilical side, where they are of nearly equal height and breadth and more wedge-shaped in outline, although the final chamber is commonly relatively large and almost hemispherical in outline, occasional specimens may show only a gradual increase in size or even a final chamber smaller than the penultimate one, umbilicus small or nearly closed; sutures of the early whorls somewhat obscure on the spiral side, those of final whorl strongly curved backward and somewhat thickened although flush with the surface, radial and slightly depressed on the umbilical side; wall calcareous, finely perforate, surface smooth; aperture interiomarginal, extraumbilical-umbilical with a narrow lip, and in specimens with nearly closed umbilicus the aperture tends to become completely extraumbilical and to extend to the peripheral keel.

Hypotypes range in greatest diameter from 0.19 to 0.48 mm. and in thickness from 0.10 to 0.22 mm.

REMARKS: *Globorotalia pseudomenardii* Bolli differs from the somewhat similar *G. elongata* Glaessner in having a peripheral keel, thickened and flush, rather than incised, sutures, which are more strongly curved on the spiral side, and a more gradual increase in chamber size and less enlarged final chamber, resulting in a less elongate test. The spiral side is gently convex, with flush chambers and sutures in all whorls, whereas in *G. elongata* the more incised radial and spiral sutures give a depressed appearance to the early whorls.

*Globorotalia membranacea* (Ehrenberg) of Toulmin is identical with this species, the original figures showing well the characteristic peripheral keel and thickened and curved sutures on the spiral side. *Planulina membranacea* Ehrenberg was originally recorded from Cretaceous chalk and two specimens were figured by

transmitted light. No description was given and no depository cited for the types. As keeled *Globorotalia* is not found in the Cretaceous, Ehrenberg's form is undoubtedly not identical with the present species, and the only available evidence (the original figures) could place the form in almost any coiled genus. It is therefore unrecognizable.

TYPES AND OCCURRENCE: Figured hypotype (USNM P5701) from the Matthews Landing marl member of the Porters Creek clay, Naheola Landing, Tombigbee River, SE¼, Sec. 30, T. 15 N., R. 1 E., 11 miles east of Jachin, Choctaw County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5702) from the Salt Mountain limestone, in a limestone sink, ¼ mile north of Salt Mountain, in the NW¼ NW¼, Sec. 34, T. 6 N., R. 2 E., Clarke County, Alabama. Collected by H. T. and A. R. Loeblich, Jr.

Figured hypotype (USNM P5703) from the Aquia formation, 15 to 17 feet above the base of the exposure, west bank of Potomac River near mouth of Aquia Creek, S. 10° E. of Brent Point, on U. S. Geological Survey Nanjemoy, Md.-Va. Quadrangle, 1:62,500, 1913, reprinted 1945. Collected by A. R. Loeblich, Jr., and Richard A. Page.

Figured hypotype (USNM P5704) from the Horners-town formation, north bank of Shingle Run, a tributary to Crosswicks Creek, 1.0 mile north of New Egypt, Monmouth County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured hypotypes (USNM P5137a-d) from the Vincentown limesand, along north bluff of Rancoocas Creek, 0.3 to 0.5 mile northwest of Vincentown, Burlington County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured hypotype (USNM P5706) from the *Ostrea thirsae* beds of the Nanafalia formation, approximately 56 feet above contact with the Midway, in road cut 1.2 mile east of Kimbrough Station and 0.2 mile east of the Turkey Creek Bridge, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5887) from the Velasco formation, middle bed at road crossing of arroyo halfway between San José de las Rusias and Soto la Marina, Tamaulipas, Mexico. Collected by R. Wright Barker.

*Globorotalia pseudoscitula* Glaessner

PLATES 46, FIGURES 4a-c; 48, FIGURES 3a-c; 53, FIGURES 5a-c; 59, FIGURES 2a-c; 63, FIGURES 6a-c

*Globorotalia pseudoscitula* GLAESSNER, Studies in Micropaleontol., Univ. Moscow Lab. Paleontol., vol. 1, No. 1, pp. 32, 49, text figs. 3a-c, 1937.

Test free, trochospiral, biconvex, almost lenticular in form, umbilicus small to nearly closed, peripheral margin subacute, peripheral outline very slightly lobulate; chambers appearing lunate from the spiral side, inflated and broadly cuneate from the umbilical side, ovate to almost angular rhomboid in section, increasing gradually in size as added, 5, or more rarely 6 to 7, in the final whorl; sutures nearly flush, curved, oblique and

somewhat thickened on the spiral side, nearly straight and radial on the umbilical side; wall calcareous, finely perforate, surface smooth to lightly spinose; aperture interiomarginal, extraumbilical-umbilical, a low arch which may show a narrow bordering lip.

Hypotypes range in diameter from 0.20 to 0.38 mm. and in thickness from 0.11 to 0.23 mm.

REMARKS: *Globorotalia pusilla laevigata* Bolli from the Paleocene of Trinidad is a very similar form and undoubtedly related to the present species.

*Globorotalia pseudoscitula* differs from *G. convexa* Subbotina in being more lenticular in section, with a more convex spiral side rather than a flattened one and a less inflated umbilical side, with nearly closed umbilicus.

TYPES AND OCCURRENCE: Figured hypotype (USNM P5139) from the Vincentown formation, north bluff of Rancocas Creek, 0.3 to 0.5 miles north of Vincentown, Burlington County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured hypotype (USNM P5130) from the Aquia formation, 15 to 17 feet above the base of the section exposed, west bank of Potomac River near mouth of Aquia Creek, S. 10° E. of Brent Point on U. S. Geological Survey Nanjemoy Md.-Va. Quadrangle, 1:63,500, 1913, reprinted 1945.

Figured hypotype (USNM P5140) from the Salt Mountain limestone, in a limestone sink ½ mile north of Salt Mountain, in the NW¼NW¼, Sec. 34, T. 6 N., R. 2 E., Clarke County, Alabama. Collected by H. T. and A. R. Loeblich, Jr.

Figured hypotype (USNM P5895) from the Velasco formation, middle bed at road crossing of arroyo halfway between San José de las Rusias and Soto la Marina, Tamaulipas, Mexico. Collected by R. Wright Barker.

Figured hypotype (USNM P5870) from the Coal Bluff marl member of the Naheola formation, in creek bottom just west of store at Caledonia, about ¼ mile south of center of Sec. 29, T. 11 N., R. 10 E., Wilcox County, Alabama. Collected by F. Stearns MacNeil.

*Globorotalia pseudotopilensis* (Subbotina)

PLATE 60, FIGURES 2a-c

*Acarinina pseudotopilensis* SUBBOTINA, Trudy Vses. Neft. Naukno-Issledov. Geol.-Razved. Inst., new ser. vol. 76, p. 227, pl. 21, figs. 8, 9; pl. 22, figs. 1-3, 1953.

Test free, trochospiral, inflated, periphery broad, subtruncate but not angular, peripheral outline lobulate, with final chamber broadest somewhat above its base and presenting a trapezoidal appearance, umbilicus small, umbilical shoulder rounded; chambers in about two whorls, 4 in the final whorl, final chamber comprising about one-third of the test; sutures distinct, nearly radial and constricted on both sides; wall calcareous, finely perforate, hispid in appearance, covered with prominent blunt spines, which are strongest in the peripheral area; aperture an arched interiomarginal extraumbilical opening.

Greatest diameter of figured hypotype 0.30 mm.

REMARKS: This species was originally described from the Paleocene and lower Eocene of Russia. It occurs rarely in the Nanafalia formation (*Ostrea thirsae* beds) of Alabama.

*Globorotalia pseudotopilensis* differs from *G. angulata* (White) in the rounded margins, instead of having a peripheral keel, in the much more strongly spinose surface, and more elevated chambers.

TYPES AND OCCURRENCE: Figured hypotype (USNM P5869) from the Nanafalia formation, south valley wall of Shoal Creek, 5.5 miles southeast of Camden, along the Camden-Fatama road, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

*Globorotalia reissi* Loeblich and Tappan, new species

PLATES 50, FIGURES 3a-c; 58, FIGURES 3a-c; 60, FIGURES 7a-c

Test free, trochospiral, periphery subangular, peripheral outline lobulate, strongly convex on the spiral side where the 2½ whorls may be seen with the early whorls raised distinctly above the level of the 5 to 6 chambers in the final whorl; chambers of greater breadth than height, increasing gradually in size as added; sutures distinct, depressed, slightly curved on the spiral side, radial on the umbilical side; wall calcareous, finely perforate, surface smooth; aperture a low extraumbilical-umbilical arch, with a narrow bordering lip above.

Greatest diameter of holotype 0.16 mm.

REMARKS: This species is closest in appearance to *G. perclara*, new species, but differs in the more elevated spire, and smooth rather than spinose surface. It differs from *G. imitata* Subbotina in the more lenticular form, with subglobular periphery, and the more numerous chambers per whorl.

The specific name is in honor of Dr. Z. Reiss, micropaleontologist, Geological Survey of Israel.

TYPES AND OCCURRENCE: Holotype (USNM P5835) from the Aquia formation, 0 to 3 feet above base of the exposure, west bank of Potomac River, near mouth of Aquia Creek, S. 10° E. of Brent Point on U. S. Geological Survey Nanjemoy Md.-Va. Quadrangle, 1:62,500, 1913, reprinted 1945. Collected by A. R. Loeblich, Jr., and Richard A. Page.

Figured paratype (USNM P5836) from the Horners-town formation, north bank of Shingle Run, a tributary to Crosswicks Creek, 1.0 mile north of New Egypt, Monmouth County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

Figured paratype (USNM P5837) from the Nanafalia formation, south valley wall of Shoal Creek, 5.5 miles southeast of Camden, on the Camden-Fatama road, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

This species also occurs in the Coal Bluff marl member of the Naheola formation of Alabama and the Matthews Landing marl member of the Porters Creek clay of Alabama.

*Globorotalia rex* Martin

PLATE 60, FIGURES 1a-c

*Globorotalia rex* MARTIN, Stanford Univ. Publ., Univ. Ser., Geol. Sci., vol. 3, No. 3, p. 117, pl. 8, fig. 2, 1943.

Test free, planoconvex, spiral side flattened, umbilical side convex to subconical, umbilicus small, periphery keeled, peripheral outline slightly lobulate; chambers increasing rapidly in size, commonly with 4 chambers in the final whorl, final chamber comprising  $\frac{1}{2}$  to  $\frac{3}{8}$  of the umbilical side, chambers gently convex at the umbilical shoulder; sutures somewhat indistinct on the spiral side, very gently curved, thickened and may be flush or very moderately elevated, especially near the peripheral margin, sutures radial and depressed on the umbilical side; wall calcareous, finely perforate, surface smooth on spiral side, with a granulated appearance on the umbilical side, becoming rougher toward the peripheral margin to appear somewhat spinose, peripheral keel somewhat beaded; aperture a very low interiomarginal, extraumbilical-umbilical arch.

Greatest diameter of hypotypes 0.38 mm.

REMARKS: *Globorotalia rex* differs from *G. angulata* (White) in the flat spiral side with flush sutures, rather than the uneven spiral side and depressed sutures. It has a less markedly lobulate periphery, more pronounced keel, less angular umbilical shoulder and smaller umbilicus.

TYPES AND OCCURRENCE: Figured hypotype (USNM P5867) from the Nanafalia formation, top of exposure of *Ostrea thirsae* beds, road cut 0.2 mile east of Turkey Creek bridge, 1.2 miles east of Kimbrough Station, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

This species was originally described from the Lodo formation of California.

*Globorotalia strabocella* Loeblich and Tappan, new species

PLATE 61, FIGURES 6a-c

Test free, of medium size, trochospiral, sides moderately convex, umbilical shoulder rounded, umbilicus broad and open, periphery broadly rounded, peripheral outline lobulate; chambers increasing gradually in size as added, of greater breadth than height, 4 per whorl in the early stages, increasing to 5 or 6 per whorl in the adult, early whorls somewhat elevated above the level of the final whorl, each successive chamber on the spiral side added somewhat below the level of that preceding, resulting in an imbricated appearance; sutures distinct, depressed, curved and oblique on the spiral side, radial and nearly straight on the umbilical side; wall calcareous, finely perforate, surface finely spinose, especially on the umbilical side; aperture an interiomarginal, extraumbilical-umbilical opening extending to the periphery.

Holotype is 0.33 mm in greatest diameter.

REMARKS: *Globorotalia strabocella*, new species, differs from *G. apantesma*, new species, in the more elevated early whorls and less truncate spiral side, broadly

rounded instead of subacute periphery, more rounded chambers and less curved sutures on the spiral side.

It differs from *Globigerina mckannai* White in being somewhat more compressed, with less globular chambers and a more extraumbilical aperture. *G. mckannai* may have been ancestral to the present species.

The specific name is from the Latin *strabus*, oblique, and *cella*, chamber, referring to the oblique attachment of successive chambers on the spiral side.

TYPES AND OCCURRENCE: Holotype (USNM P5879) from the Nanafalia formation, south valley wall of Shoal Creek, 5.5 miles southeast of Camden, along the Camden-Fatama road, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

The species also occurs rarely in the Vincentown formation.

*Globorotalia tribulosa* Loeblich and Tappan, new species

PLATES 56, FIGURES 3a-c; 61, FIGURES 7a-c

Test free, trochospiral, biconvex, spire nearly flat, umbilicus small and deep, periphery rounded, peripheral outline lobulate; chambers globular, increasing rapidly in size, forming about  $2\frac{1}{2}$  whorls, commonly with 4 to 5 chambers in the final whorl; sutures distinct, constricted, gently curved to radial; wall calcareous, distinctly perforate throughout, surface finely but prominently hispid; aperture an interiomarginal, extraumbilical-umbilical, high, broad arch.

Greatest diameter of holotype 0.30 mm. Paratype 0.28 mm. in diameter.

REMARKS: The species somewhat resembles *Globorotalia pseudobulloides* (Plummer) in general appearance, differing in the spinose surface. It differs from *Globigerina esnaensis* LeRoy in being much smaller, and in having more globular chambers.

The specific name comes from the Latin *tribulosus*, thorny, and refers to the spinose wall.

TYPES AND OCCURRENCE: Holotype (USNM P5850) from the Nanafalia formation, basal 6 feet of the formation, road cut 0.2 mile east of Turkey Creek bridge and 1.2 miles east of Kimbrough Station, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Paratype (USNM P5851) from the Aquia formation, 14 to 16 feet above the base of the exposure, west bank of Potomac River, near mouth of Aquia Creek, S. 10° E. of Brent Point on U. S. Geological Survey Nanjemoy Md.-Va. Quadrangle, 1:62,500, 1913, reprinted, 1945. Collected by A. R. Loeblich, Jr., and Richard A. Page.

*Globorotalia trichotrocha* Loeblich and Tappan, new species

PLATES 50, FIGURES 5a-c; 57, FIGURES 1a-2c

Test free, small, trochospiral, spiral side flattened, umbilical side strongly convex and highest at the umbilical shoulder around the small deep umbilicus, periphery subangular, peripheral outline only slightly lobulate; chambers low and relatively broad on the spiral side, with 6 or more rarely 7 in the final whorl, the chambers sloping sharply outward to the periphery from the umbilical shoulder at the small umbilicus,

giving the test a low conical appearance; sutures distinct, curved obliquely backwards on the spiral side, radial on the umbilical side; wall calcareous, finely perforate, entire surface may be hispid, but with early spire most prominently spinose, final one or two chambers may be somewhat more smooth; aperture a very small interiomarginal, extraumbilical-umbilical arch.

Holotype 0.23 mm. in diameter.

REMARKS: *Globorotalia trichotrocha*, new species, is one of a closely related group of species, all of small size with flattened spiral side, rounded or subacute peripheral angle and spinose surface. It differs from *G. conicotruncata* Subbotina in its smaller size, fewer chambers per whorl and narrower umbilicus. *Globorotalia perclara*, new species, differs in having more lobulate periphery, and relatively high, subglobular chambers which are evenly convex on the umbilical side without a prominent umbilical shoulder, and in having a less hispid surface; *G. reissi*, new species, has a convex spiral side, a more lobulate periphery, chambers evenly rounded on the umbilical side, sutures nearly radial instead of oblique on the spiral side.

The specific name is from the Greek *thrix*, *trichos*, hair, and *trochus*, wheel.

TYPES AND OCCURRENCE: Holotype (USNM P5355) and figured paratype (USNM P5705) from the Aquia formation, 3 to 6 feet above base of section exposed, west bank of Potomac River, near mouth of Aquia Creek, S. 10° E. of Brent Point on U. S. Geological Survey Nanjemoy Md.-Va. Quadrangle, 1:62,500, 1913, reprinted 1945. Collected by A. R. Loeblich, Jr., and Richard A. Page.

Figured paratype (USNM P5690) from the Horseshoe formation, north bank of Shingle Run, a tributary to Crosswicks Creek, 1.0 mile north of New Egypt, Monmouth County, New Jersey. Collected by A. R. Loeblich, Jr., and Norman Sohl.

*Globorotalia troelseni* Loeblich and Tappan, new species

PLATES 60, FIGURES 4a-c; 63, FIGURES 5a-c

Test free, medium sized, compressed trochospiral, 1½ to 2 whorls visible on the spiral side with the early spire somewhat depressed, umbilical side with an open umbilicus with portions of earlier whorls visible within, due to the tendency of the final whorl to uncoil slightly and appear somewhat evolute, periphery subacute with a slight keel, peripheral margin lobulate; 5 to 6 chambers in the final whorl, moderately inflated, of nearly equal breadth and height, increasing gradually in size as added; sutures distinct, depressed, gently curved on the spiral side, nearly radial on the umbilical side; wall calcareous, distinctly perforate, surface smooth; aperture interiomarginal, extraumbilical-umbilical, a relatively high arch extending to the periphery, bordered above with a very narrow lip.

Holotype 0.26 mm. in greatest diameter.

REMARKS: This species is characterized by its tendency to become evolute, so that the early whorls are visible from both the spiral and umbilical sides. It is

closest in appearance to *Globorotalia pseudomenardi* Bolli, differing in the evolute tendency, and more numerous chambers, which are more equally inflated on the two sides. It has been observed only in the Nanafalia and Velasco formations.

This species is named in honor of Dr. John C. Troelsen, University of Copenhagen, Denmark, in recognition of his work on the Paleocene and lower Eocene Foraminifera.

TYPES AND OCCURRENCE: Holotype (USNM P5687) from the Nanafalia formation (*Ostrea thirsae* beds), 56 feet above the Midway contact, in road cut 1.2 mile east of Kimbrough Station and 0.2 mile east of the Turkey Creek bridge, Wilcox County, Alabama. Collected by A. R. Loeblich, Jr.

Paratype (USNM P5896) from the Velasco formation, middle bed at road crossing of arroyo halfway between San José de las Rusias and Soto la Marina, Tamaulipas, Mexico. Collected by R. Wright Barker.

*Globorotalia varianta* (Subbotina)

PLATES 44, FIGURES 1a-2b; 45, FIGURES 4a-c

*Globigerina varianta* SUBBOTINA, Trudy Vses. Neft. Nauchno-Issledov. Geol.-Razved. Inst., new ser., vol. 76, p. 63, pl. 3, figs. 5-12; pl. 4, figs. 1-3; pl. 15, figs. 1-3.

Test free, medium sized, low trochospiral coil of approximately 2½ whorls, umbilical side with small and deep umbilicus; chambers subglobular and inflated, increasing rapidly in size, 5 to 6 in the final whorl; sutures distinct, constricted; wall calcareous, distinctly perforate, surface prominently spinose, especially in the early chambers, later chambers becoming less spinose; aperture extraumbilical-umbilical, a high open arch extending to the periphery and bordered above by a subtriangular lip which is widest at its midpoint and tapers toward the periphery and umbilicus.

Hypotypes range from 0.23 to 0.40 mm. in diameter.

REMARKS: This species is similar in size and plan of growth to *G. pseudobulloides* (Plummer) and has probably been confused with that species in the past. It differs in having a prominently spinose surface and is less coarsely perforate.

TYPES AND OCCURRENCE: Figured hypotypes (USNM P5707a,b) from the Mexia clay member of the Wills Point formation, in abandoned pit of the Mexia Brick Works at Mexia, Limestone County, Texas. Collected by A. R. Loeblich, Jr.

Figured hypotype (USNM P5708) from the Matthews Landing marl member of the Porters Creek clay at Naheola Landing on the Tombigbee River, SE¼, Sec. 30, T. 15 N., R. 1 E., 11 miles east of Jachin, Choctaw County, Alabama. Collected by A. R. Loeblich, Jr.

*Globorotalia velascoensis* (Cushman)

PLATE 64, FIGURES 1a-2c

*Pulvinulina velascoensis* CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 1, p. 19, pl. 3, figs. 5a-c, 1925.

Test free, trochospiral, spiral side flattened, umbilical side with the chambers much elevated at the umbilical



shoulder around the broad and open umbilicus, the umbilical shoulder strongly thickened, highly spinose, and may even form an everted collar, chamber wall sloping sharply in both directions from this umbilical shoulder, periphery with a distinct, wide and spinose keel, peripheral outline lobulate; chambers increasing gradually in size, 7 to 9 in the final whorl; sutures distinct, thickened, elevated, oblique and beaded on the spiral side, radial, depressed and straight on the umbilical side; wall calcareous, finely perforate, ornamented with the beaded sutures, beaded or spinose peripheral keel, and thickened and spinose collar at the umbilical shoulder; aperture an interiomarginal, extraumbilical-umbilical arch with a narrow lip.

Hypotypes range from 0.42 to 0.60 mm. in diameter.

REMARKS: This species is characterized by the limbate and beaded sutures, wide umbilicus and highly ornate collar at the umbilical shoulder. *Globorotalia acuta* Toulmin differs in lacking the beaded sutures, and in having fewer chambers per whorl. *Globorotalia apantesma*, new species, lacks the umbilical collar, and has depressed sutures on the spiral side. *Globorotalia oclusa*, new species, has a very narrow umbilicus and no umbilical collar.

TYPES AND OCCURRENCE: Figured hypotypes (USNM P5871a,b) from the Velasco formation, middle bed at road crossing of arroyo halfway between San José de las Rusias and Soto la Marina, Tamaulipas, Mexico. Collected by R. Wright Barker.

#### *Globorotalia* species

PLATE 45, FIGURES 8a-c

Test free, small, trochospiral, compressed, umbilicus tiny, peripheral outline slightly lobulate, peripheral angle subacute; chambers in about two whorls, 4½ broad low chambers in the final whorl, gently convex on the spiral side, more elevated on the umbilical side, with a rounded to subacute umbilical shoulder; sutures distinct, slightly depressed, curved and oblique on the spiral side, nearly straight and radial on the umbilical side; wall calcareous, finely perforate, surface smooth, except near the periphery where it becomes very finely hispid; aperture interiomarginal, extraumbilical-umbilical, bordered above by a narrow lip.

Greatest diameter of figured specimen 0.20 mm.

REMARKS: This species somewhat resembles *Globorotalia pseudoscitula* Glaessner, but has somewhat higher chambers on the spiral side, is less prominently perforate or punctate, is more compressed and has fewer chambers per whorl. It differs from *G. pusilla* Bolli in being more compressed, with a more flattened spiral side and higher chambers, and a more gradual increase in chamber size. Because it is quite rare it is not here described as a new species.

TYPES AND OCCURRENCE: Figured specimen (USNM P5880) from the Matthews Landing marl member of the Porters Creek clay, Naheola Landing, Tombigbee River, SE¼, Sec. 30, T. 15 N., R. 1 E., 11 miles east of Jachin, Choctaw County, Alabama. Collected by A. R. Loeblich, Jr.

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